Sequential Logistic Regression: A Method to Reveal Subtlety in Self-Efficacy

Vashti Sawtelle, Eric Brewe, and Laird H. Kramer
Florida International University, USA

Abstract: This paper uses self-efficacy to predict the success of women in introductory physics. We show how sequential logistic regression demonstrates the predictive ability of self-efficacy, and reveals variations with type of physics course. Also discussed are the sources of self-efficacy that have the largest impact on predictive ability.

Over recent decades, bachelor's degrees in physics have lagged behind the numbers being awarded in other fields. The latest American Institute of Physics poll found that only 2% of all science, math, engineering, and natural science bachelor's degrees were awarded in physics (Mulvey & Nicholson, 2007). Specifically, women only make up about 21% of all of the physics bachelor's degrees awarded (Mulvey & Nicholson, 2007). In order to remain a thriving field in science, physics educators need to focus their attention on increasing the representation of all students in physics, as well as the participation of women.

Equity in science literature shows that trying to understand why women are not persisting in physics is not a new area of inquiry for science educators. Researchers in physics education have focused on characterizing the gender gap on conceptual understanding assessments in physics (Blue & Heller, 2003; Hake, 2002; Kost, Pollock, & Finkelstein, 2009; Robertson, 2006) and ameliorating this gender gap (Brewe et al., 2010; Lorenzo, Crouch, & Mazur, 2006; McCullough, 2004). However, since the late 1980's, there has been a shift in the science education literature toward focusing on creating gender inclusive classrooms (Baker, 2002). Another line of research suggests that self-efficacy may provide a predictive link between confidence in ability and success in the science classroom. Science self-efficacy has been linked to persistence in science majors and career choices in science as well as achievement (Andrew, 1998; Dalgety & Coll, 2006; Lent, Brown, & Larkin, 1986, 1987, 1989; Luzzo et al., 1999; Pietsch, Walker, & Chapman, 2003). These studies indicate that examining the details of self-efficacy may provide a mechanism for understanding why some students, particularly women, persist in the sciences while others do not.

Self-Efficacy

Bandura (1977) defined self-efficacy to be the beliefs in one's ability to perform a *specific* task, emphasizing the specificity of the task. According to Bandura's (1997) social cognitive theory, an individual's self-efficacy is derived from interpreting information from four experiential sources. The first, and Bandura theorized the most influential, source of self-efficacy is that of *personal mastery experiences* (*ME*). Experiences where an individual successfully completes a task would have a positive impact on self-efficacy, while repeated failures would have a negative influence. The second source, *vicarious learning experiences* (*VL*), is characterized by observing another person modeling a similar task to the one being considered. Observing someone else's success and/or failure is particularly important when the individual has little to no experience with the task. The third source, *social persuasion experiences* (*SP*), comes from messages from society, parents, or instructors. These messages, Bandura argued, are particularly influential for people who already believe themselves capable

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of performing the task. Finally, the fourth source, the *physiological state* (*PS*) of a person, works by mediating other sources to amplify or undermine confidence in one's ability to perform a task.

Self-Efficacy and Women

The social cognitive theory of self-efficacy provides a mechanism for understanding the information that women rely on when making decisions about their abilities to succeed in physics. Betz and Hackett (1981) published a seminal work on the relationship between self-efficacy and the career choices women and men make, finding that women had significantly lower self-efficacy scores than men with regard to completing the educational requirements of many historically male-dominated occupations, such as accounting and engineering. Betz and Hackett (1981) also linked these self-efficacy scores to the type of occupations men and women considered as career options, with men more likely to consider historically male-dominated occupations like mathematics and engineering. In another study, Matsui, Matsui, and Ohnishi (1990) showed that gender is a unique contributor to self-efficacy development in mathematics, with men having higher self-efficacy than women. Physics shares many of the same educational requirements and job duties as both engineering and mathematics, and as such, these findings are suggestive of the relationship between self-efficacy and choice of physics as a career option.

Evidence furthering the argument for using self-efficacy to understand differences in persistence for women and men comes from studies investigating the influence of gender on the four sources of self-efficacy beliefs. In a theoretical analysis, Hackett and Betz (1981) discussed Bandura's theory of self-efficacy beliefs, by understanding how the four sources may explain self-efficacy differences between women and men in various fields. They suggested that women and men rely on different types of information in their daily lives, and that these differences most likely influence how each group considers its prospects as professionals. Similarly, Zeldin et al. (2000, 2008) examined the relationship between gender and sources of self-efficacy by completing two extensive qualitative studies with men and women who succeeded in rising in STEM careers. Zeldin and Pajares (2000) found that women recalling experiences that impacted their decision to continue in a science or math career described events that were primarily identifiable as *vicarious learning* and *social persuasion* experiences. Subsequently, Zeldin, Britner, and Pajares (2008) found that men, in similar life positions, recalled primarily personal *mastery experiences*. Although these results do not all tell the same story, gender differences connect them.

At this time, little research has been done investigating the development of student self-efficacy in physics, and what we have does not paint a clear picture. One study showed a negative relationship between self-efficacy and physics course achievement (Gungor, Eyilmaz, & Fakioglu, 2007); another contradicted these results by showing self-efficacy best predicted physics conceptual understanding as well as physics grade (Cavallo, Potter, & Rozman, 2004). This small body of literature indicates there is little consensus about the role self-efficacy plays in physics at this point, but from the larger science self-efficacy literature, it is clear that self-efficacy is an information rich and beneficial avenue of study for physics retention. In thinking about the role self-efficacy might play in understanding the scarcity of women in physics, it is important to carefully choose appropriate methods in both the measuring of self-efficacy as well as analyzing the impacts of self-efficacy. In this paper we will provide an argument for investigating the subtle interactions within self-efficacy.

Method

Investigating how self-efficacy can be used to understand the lack of women in physics requires us to take a stance on what methods are and are not appropriate. The first consideration in this investigation is gender. As several researchers have noted, simply comparing female scores to male scores on various diagnostics, and looking at the differences between them, often leads researchers toward a framework where the underlying assumption is that women should be more like men (Baker, 2002) also often referred to as the deficit model (Baker & Leary, 1995; Gutiérrez, 2008; Nichols et al., 1998; Scantlebury & Baker, 2007). Thus, rather than characterizing differences between women and men, we choose a method that focuses on understanding the subtleties in the relationship between self-efficacy and the success of women alone. The second question then becomes one defining success. Since passing the Introductory Physics with Calculus 1 course is a prerequisite to taking any other courses in physics, and thus in becoming a major, instead of focusing on grade received in the course, we attempt to predict the probability of a woman passing the Introductory Physics course. The variables used for this prediction are the different sources of self-efficacy. Thus, our method of analysis should create models that predict dichotomous outcomes (pass/fail) through a combination of continuous (self-efficacy) and categorical (course type) predictor variables. Additionally, our method capitalizes on the self-efficacy literature that has looked at the how the various sources of self-efficacy may be more important for the success of women than others. Logistic regression, as an analysis technique, focuses on creating models that predict group membership from a set of previously determined predictor variables. The ultimate goal in logistic regression is to find the best combination of predictor variables that maximize the likelihood of correctly assigning a case to the observed group (Tabachnick & Fidell, 2007). Further, a sequential logistic regression (SLR) technique allows us to specify the order with which our predictor variables enter the model and capitalize on the prior research on sources of self-efficacy. SLR also provides this mechanism through a comparison of coefficients in front of each variable in the model, allowing for a calculation of the size of the effect of each.

Predictor Variables

To assess the physics self-efficacy beliefs of students in the beginning of the semester, we use the Sources of Self-Efficacy in Science Courses - Physics (SOSESC-P) survey. The SOSESC-P was developed by Fencl and Scheel (2005) to probe the four sources of self-efficacy as described by Bandura (1997). The survey is a 33-item assessment that asks students to indicate how strongly they agree with statements about their ability in their physics class on a 5-point Likert scale (see Table 1 for example statements), and is disaggregated into four subscales by the four sources of self-efficacy. Internal consistency reliability alpha coefficients range from .68 (SP) to .88 (PS) with the coefficient for the total scale at .94. In addition, all SOSESC-P subscales and the total scale correlate significantly and positively with scores on the Self-Efficacy for Academic Milestones-Strength scale (Brown, Lent, & Larkin, 1986), a well-established measure of global self-efficacy in science and technology fields (Fencl & Scheel, 2005). The SOSESC-P is given to all introductory students in a PRE/POST format where the PRE portion is completed within the first 3 weeks of the start of classes. This paper focuses only on the PRE portion of the survey. In addition to collecting SOSESC-P data, demographic data including gender and ethnicity was retrieved from the university database system. The students self-report ethnicity and gender, choosing from Asian, Black, Hispanic, Native American, White, or Not Reported, and from Female, Male, and Not Reported for gender. This institution is an urban research university enrolling 39,146 students in Fall 2009, of which nearly 60% are Hispanic and 57% are female (University Factbook, 2009). Students' final grade point in Physics with Calculus I was also retrieved from the university database system. Students who received an Incomplete were excluded from the data analysis as the official grade may still change.

All students included in this study are enrolled in a Physics with Calculus I course. However, this Hispanic serving institution offers two types of courses in introductory physics: Modeling Instruction (MI) and traditional Lecture. MI is a reform effort that has had great success in improving student conceptual gains as well as improved retention rates (Brewe et al., 2010). The development of MI was guided by the Modeling Theory of Science (Hestenes, 1987), which focuses on the process of building, validating, and deploying scientific models. The MI course at this institution operates as a collaborative learning environment, with thirty students in a studio-format class with integrated lab and lecture. It is already well documented that the MI course significantly improves the retention of all students in the course, including women (Brewe et al., 2010). However, our intention is not to compare instructional methods, but to understand the influence of self-efficacy. Nonetheless, we have participants from two different course types to create an interaction variable between Course Type and the sources of self-efficacy (*ME*, *VL*, and *SP*). The original variable coding can be seen in Table 2.

Outcome Variable

When researchers have explored the predictive nature of self-efficacy, they typically describe the dependent variable as some form of success (Hackett & Betz, 1989; Lent et al., 1986, 1987; Stipek, 1996). Following Fencl and Scheel's (2006) lead, we define success as retention in the Introductory Physics course. Thus, there are two options for a single student: they may successfully pass (a grade of C^- or above) or fail the course (a grade of D^+ or below, Drop, or Withdraw). Thus our outcome variable is a dichotomous one, Pass or Fail.

Participants

A total of 352 of the 620 students enrolled in the Introductory Physics with Calculus 1 course, in either Fall 2008 or Spring 2009, responded to the SOSESC-P survey via a total of six e-mail requests. Students who responded to the survey were representative of the larger sample in gender and ethnicity. Of the 352 students who responded to the SOSESC-P survey, 8 people completed less than 80% of the items in the survey and were removed from the data set. The data from 331 students' responses to the SOSESC-P survey were used in this analysis. No significant differences between the sample population and the students removed from the data set were found. The demographic information for all 331 students was collected via the University Database. The demographic and Modeling Instruction/Lecture distributions of all students in this study are provided in Figure 1, and are approximately representative of the student body at this institution.

Analytic Approach

As discussed above, sequential logistic regression (SLR) builds models that predict a dichotomous outcome (pass/fail) through a combination of continuous (SOSESC-P score) and categorical (course type) variables, while capitalizing on prior research. The intention of the SLR technique is to focus the interpretation of results on whether a particular variable significantly adds to the model's ability to predict the probability of the outcome when you have a theoretical ordering to the variables entered into the model (Tabachnick & Fidell, 2007). In this study, we focus on how SLR can reveal subtleties in how self-efficacy predicts the success of women in Introductory Physics. To this end, we focus both on how well the model (represented by Model 1 below) predicts the observed outcomes, as well as how the effect size (the odds ratio) of the coefficients of each variable (β_1 and β_2) in the model compare. Within each model, maximum likelihood parameter estimates were used to determine the coefficients of the predictor variables.

Model 1: $\hat{Y}_i = \frac{e^{\beta_0+\beta_1 X_1+\beta_2 X_2}}{1+e^{\beta_0+\beta_1 X_1+\beta_2 X_2}}$

The sequential logistic regression analysis and statistical software used in this study are thoroughly explained in Tabachnick and Fidell (2007) and Pallant (2007). Using SPSS 16.0, we computed four different models using various combinations of the sources of self-efficacy to predict the success of women in introductory physics. Goodness of fit with the observed data was obtained through evaluating the effect of omitting a predictor variable. If a significant difference between the predictive ability of *Model 1* and *Model 2* is found, then the data would suggest that variable X_2 is necessary in the model. The goal in SLR analysis is to find the simplest model that sufficiently predicts the observed data.

Model 2: $\hat{Y}_i = \frac{e^{\beta_0+\beta_1 X_1}}{1+e^{\beta_0+\beta_1 X_1}}$

Categorical predictors were recoded into dummy variables before being entered into the SLR models. All measures were converted to *z*-scores in order to allow for the comparison of coefficients. Pearson's *r* was evaluated as a test of multicollinearity between the variables. Variables that were multicollinear were not included in the final models. As with most studies, this one is not free of limitations. First, the sample size, when disaggregated by gender especially, is not large. All of the statistical assumptions were met with the data set included in the analysis, and conclusions drawn from this relatively small sample are useful and relevant for the science education community.

Results

We completed two correlation tests on the PRE SOSESC-P data. Table 2 shows results of correlation tests between PRE scores (Average and the four sources) and the final grade point a student receives in the course. Results indicate a significant correlation between the average self-efficacy and grade point ($r = .299$, $p < .001$) as well as for individual sources of self-efficacy and grade point for both men and women. The correlation with average self-efficacy, which accounts for 9% of the variance in the Female grade point, suggests that our choice of using passing as the dependent variable is a reasonable one. The second correlation tested the relationship between scores on individual sources of self-efficacy as measured by the SOSESC-P. As seen in Table 2, all of the sources are strongly correlated, suggesting the use of multivariable statistics. However, the *physiological state (PS)* source of self-efficacy is correlated at a very high ($r = .848$) level with the personal *mastery experiences (ME)* source. In order to avoid multicollinearity, which would violate the assumptions even for multivariate statistics, we chose to remove the *PS* source from the rest of the analysis and allow the *ME* source serve as the variable alone. This is consistent with the theoretical work of Bandura (1997) and Hackett (1981) who showed that *PS* is more a mediating cofactor, varying with the other sources, than an independent factor.

The qualitative results of Zeldin and Pajares (2000) indicate that for the purpose of evaluating the success of female students, we should consider the influence of both the *vicarious learning* (*VL*) source of self-efficacy as well as the *social persuasion* (*SP*) source of self-efficacy beliefs. Accordingly, Model 1 for the female specific model includes the interaction variables between course-type and both the *VL* and *SP* sources. As seen in Table 3, results indicate that the fit for Model 1 to the observed data is a good with $\chi^2(4, n = 133) = 14.247$, $p < .05$, and correctly predicts 69.9% of the cases.

Discussion

In using sequential logistic regression as an analysis technique, we focused our study on the subtleties that could be revealed in the predictive relationship of self-efficacy on success for women in introductory physics. In Zeldin and Pajares' work (2000), their results indicated that women strongly relied on both *vicarious learning* experiences, as well as *social persuasion* experiences. However, we found in this study, as seen in Model 2 of Table 3, that when excluding the *SP* from the model, there is no significant difference between Model 2 and Model 1. This suggests that *SP* score is not a significant predictor for female students passing the introductory physics course. Moreover, in Model 3 when we eliminate *VL* we do see a significant difference between Model 3 and Model 1. This suggests the *VL* score significantly predicts female student success in introductory physics. Additionally, regardless of the other source variables present, including the *ME* score, the model shows no significant improvement to the fit.

A review of the parameter estimates for the Model 1, in Table 4, including both *VL* and *SP* scores further supports the inclusion of the *VL* score in the model. However, regarding the odds ratios for the variables, the only effect size that shows a distinct positive relationship with predicting the passing of a female student is the interaction between *Modeling* and *VL* score. All the other confidence intervals on the odds ratios range from numbers less than one to numbers greater than one. Thus the variable we can confidently say predicts the success of female students in Introductory Physics is the interaction variable *Modeling**VL*, with a student who has a high *VL* score being much more likely to pass the course than a student with a low *VL* score.

However, the SLR technique uncovers a further subtlety in the effect of *vicarious learning* experiences on retention in introductory physics. In our results we show that only *VL* * Modeling Instruction has a clear positive effect on the prediction of a female student passing the Introductory Physics course, while the contribution of *VL* * Lecture instruction is much smaller. To understand this varying result, we consider the differences between MI and traditional Lecture instruction in conjunction with literature on women in science. Many studies investigating the impact of curriculum on women found that particular features have positive influences on all students, including women: curriculum focusing on integrating student experiences, and classrooms that assessed in a variety of forms that centered on collaboration and provided opportunities for active participation (Brotman & Moore, 2007). Also, the features listed above provide opportunities for students to model tasks and get direct comparison information, providing opportunities for *VL* experiences. MI places great emphasis on elements such as those outlined above. For example, the MI course stresses collaboration by giving one of the three in-class exams as a group exam, where the students are expected to work together in teams to produce one final copy of the exam to be graded. MI not only provides opportunities for *VL* experiences, but also emphasizes their importance. In contrast, in the traditional Lecture environment, students are expected to develop knowledge completely individually, with this message being reinforced by lecture classes where students are discouraged from talking with one another, homework assignments that are randomized such that students cannot work together on solving problems, and exam grades that are often curved to the highest grade in the class. The main features of the Lecture classes provide little opportunity for the development of *VL* experiences. The differences between the two course types become obvious to students after the first couple days of class and the emphasis, or lack thereof, on *VL* experiences may play a role in reducing the size of the contribution of this source in the Lecture course.

Conclusions

As demonstrated in this paper, SLR reveals subtleties in the predictive nature of self-efficacy for success for women in physics. The very nature of the analysis shows us not only what sources best work to predict the success of women in physics, but also how those sources interact with the type of course students are enrolled in. Had we simply done a comparison study of the differences between women and men, we may have only found that they differ in sources of self-efficacy. However, through the use of SLR, we have shown that even within the group of women, the relationship of success with self-efficacy is very subtle. Thus, we make two suggestions to future researchers: (a) when using self-efficacy to predict success, keep in mind that the sources of self-efficacy may vary greatly between groups of individuals as well as by the context being examined, and (b) weigh your analysis techniques carefully, and when looking for subtleties in predictions, consider sequential logistic regression as a possibility.

References

Andrew, S. (1998). Self-efficacy as a predictor of academic performance in science. *Journal of Advanced Nursing, 27*(3), 596-603.

Brewe, E. (2008). Modeling theory applied: Modeling instruction in introductory physics. *American Journal of Physics, 76*, 1155. doi:10.1119/1.2983148

Brewe, E., Sawtelle, V., Kramer, L. H., O'Brien, G. E., Rodriguez, I., & Pamelá, P. (2010). Toward equity through participation in modeling instruction in introductory university physics. *Physical Review Special Topics Physics Education, 6*(1), 0106. doi:10.1103/PhysRevSTPER.6.010106

Baker, D., & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching, 32*(1), 3-27.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura, A. (1997). In Brennan S. F., Hastings C. (Eds.), *Self-efficacy: The exercise of control*. New York, NY: W.H. Freeman.

Betz, N. E., & Hackett, G. (1981). The relationship of career-related self-efficacy expectations to perceived career options in college women and men. *Journal of Counseling Psychology, 28*(5), 399-410.

Brotman, J. S., & Moore, F. M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching, 45*(9), 971-1002.

Brown, S. D., Lent, R. W., & Larkin, K. C. (1989). Self-efficacy as a moderator of scholastic aptitude-academic performance relationships. *Journal of Vocational Behavior, 35*(1), 64-75.

Cavallo, A. M. L., Potter, W. H., & Rozman, M. (2004). Gender differences in learning constructs, shifts in learning constructs, and their relationship to course achievement in a structured inquiry, yearlong college physics course for life science majors. *School Science and Mathematics, 104*(6), 288-300.

Desbien, D. M. (2002). *Modeling discourse management compared to other classroom management styles in university physics.* (Unpublished PhD). Arizona State University, Arizona. (AAT 3054620)

Fencl, H., & Scheel, K. (2005). Engaging students: An examination of the effects of teaching strategies on self-efficacy and course climate in a nonmajors physics course. *Journal of College Science Teaching, 35*(1), 20-24.

Gungor, A., Eryilmaz, A., & Fakioglu, T. (2007). The relationship of freshmen's physics achievement and their related affective characteristics. *Journal of Research in Science Teaching, 44*(8), 1036-1056.

Gutiérrez, R. (2008). A "gap-gazing" fetish in mathematics education problematizing research on the achievement gap. *Journal for Research in Mathematics Education, 39*(4), 357–364.

Hake, R. R. (2002). Relationship of individual student normalized learning gains in mechanics with gender, high-school physics, and pretest scores on mathematics and spatial visualization. *Physics Education Research Conference (Boise, Idaho, August 2002),*

Hestenes, D. (1987). Toward a modeling theory of physics instruction. *American Journal of Physics, 55*(5), 440-454.

Kost, L. E., Pollock, S. J., & Finkelstein, N. D. (2009). Characterizing the gender gap in introductory physics. *Physics Review Special Topic - Physics Education Research, 5*, 010101.

Lent, R. W., & Brown, S. D. (2006). On conceptualizing and assessing social cognitive constructs in career research: A measurement guide. *Journal of Career Assessment, 14*(1), 12.

Lent, R. W., Brown, S. D., & Larkin, K. C. (1986). Self-efficacy in the prediction of academic performance and perceived career options. *Journal of Counseling Psychology, 33*(3), 265-269.

Lent, R. W., Brown, S. D., & Larkin, K. C. (1987). Comparison of three theoretically derived variables in predicting career and academic behavior: Self-efficacy, interest congruence, and consequence thinking. *Journal of Counseling Psychology, 34*(3), 293-298.

Lorenzo, M., Crouch, C. H., & Mazur, E. (2006). Reducing the gender gap in the physics classroom. *American Journal of Physics, 74*(2), 118.

Matsui, T., Matsui, K., & Ohnishi, R. (1990). Mechanisms underlying math self-efficacy learning of college students. *Journal of Vocational Behavior, 37*(2), 225-238.

McCullough, L. (2004). Gender, context and physics assessment [special issue]. *Journal of International Women's Studies, 5*(4), 20–30.

Mulvey, P. J., & Nicholson, S. (2008). *Enrollments and degrees report, 2006.* No. AIP Report Number R-151.43 Statistical Research Center of the American Institute of Physics.

Nichols, S. E., Gilmer, P. J., Thompson, A. D., & Davis, N. (1998). Women in science: Expanding the vision. In B. J. Fraser, & K. G. Tobin (Eds.), *International handbook of science education* (pp. 967-978) Kluwer Academic Publishers.

Pietsch, J., Walker, R., & Chapman, E. (2003). The relationship among self-concept, self-efficacy, and performance in mathematics during secondary school. *Journal of Educational Psychology, 95*(3), 589-603.

Robertson, L. A. (2006). Why are there so few female physicists? *The Physics Teacher, 44*, 177-180.

Scantlebury, K., & Baker, D. (2007). Gender issues in science education research: Remembering where the difference lies. In S. K. Abell, & N. Lederman (Eds.), *Handbook of research on science education* (pp. 257) Lawrence Erlbaum.

Stipek, D. J. (1996). Motivation and instruction. In D. C. Berliner & R. C. Colfee (Eds.), *Handbook of educational psychology* (pp. 85-113). New York, NY: MacMillan.

Tabachnick, B. G., & Fidell, L. S. (2007). In Hartman S. (Ed.), *Using multivariate statistics* (5th ed.). Boston, MA: Allyn and Bacon.

Wells, M., Hestenes, D., & Swackhamer, G. (1995). A modeling method for high school physics instruction. *American Journal of Physics, 63*, 606.
Zeldin, A. L., Britner, S. L., & Pajares, F. (2008). A comparative study of the self-efficacy beliefs of successful men and women in mathematics, science, and technology careers. *Journal of Research in Science Teaching, 45*(9), 1036-1058.
Zeldin, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal, 37*(1), 215.

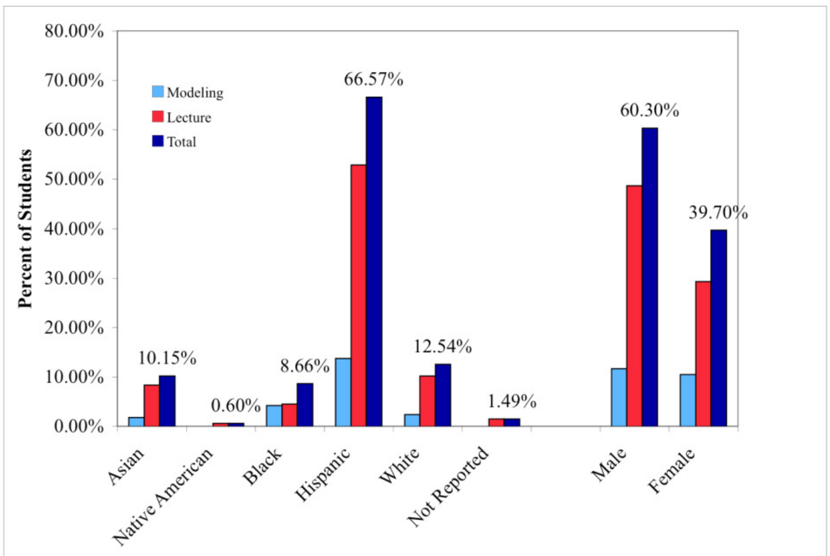

Figure 1. Demographics of introductory Physics with Calculus I students included in the data set. Numbers shown in the figure indicate the percentages for the total population.

Table 1
Examples of SOSESC-P Items Used in PRE Survey

Item Number	Item Statement	Source of Self-Efficacy
1	I am capable of receiving good grades on my assignments in this class.	Mastery Experience
7	Listening to the instructor and other students in question-and-answer sessions makes me think that I cannot understand physics. **R**	Vicarious Learning
20	I get positive feedback about my ability to recall physics ideas.	Social Persuasion

Note. **R** = Reverse Scored

Table 2

Correlations Between Sources of Self-Efficacy and Grade Point for Men and Women

	Average	ME	VP	VL	PS
			Grade Point		
Grade Point Men (n=198)	.341**	.321**	.283**	.289**	.243*
Grade Point Women (n=133)	.299**	.288**	.191**	.292**	0.159
			Sources of Self-Efficacy (n=334)		
ME	.939**	-	0.638**	0.786**	0.848**
VP	.784**	0.638**	-	0.678**	0.581**
VL	.890**	0.786**	0.678**	-	0.743**
PS	.920**	0.848**	0.581**	0.743**	-

**p<.001

Table 3

Logistic Regression Models: Evaluation of Female Model - Predicting Passing of Introductory Physics

	χ^2	df	-2LL	χ^2_{diff}	Δdf
	Female Specific Models (n = 133)				
Model 1 - VL and SP	14.247*	4	148.412		
Model 2 - VL Only	10.280*	2	152.379		
Difference between Model 2 & Model 1				3.967	2
Model 3 - SP Only	7.987*	2	154.672		
Difference between Model 3 & Model 1				6.26*	2
Model 4 - VL, SP, and ME	16.56*	6	146.099		
Difference between Model 4 & Model 1				2.313	2

*p< .05, ***p< .0005

Table 4

Logistic Regression Models: Parameter Estimates of Female Model - Predicting Passing of Introductory Physics I Course

	Coefficient	Odds Ratio	95% CI on Odds Ratio
		Female Model (n = 133)	
Interaction Variables			
Modeling*VP score	-3.928	0.02	[0, 1.520]
Modeling*VL score	5.262	192.845	[1.885, 1972.3]
Lecture*VP score	0.26	1.296	[0.261, 6.42]
Lecture*VL score	0.225	1.253	[0.296, 5.307]
Model Evaluation			
Chi-Square	14.247*		
Percentage of correct classification (PCP)	72.42		

Note. All variables are standardized such that SD =1. CI = Confidence Interval.
*p<.05, ***p<.0005