The Development of a Physics Self-Efficacy Instrument for Use in the Introductory Classroom

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Self-efficacy (SE) can be described as a person's belief in her/his own ability to accomplish a specific task to a given performance level, and is both content and context dependent. This may be especially important for female students in science, who tend to drop out of science classrooms with much better performance records than their male counterparts. The PACER group at SIUE has been developing an instrument to examine the relationship between physics SE and student performance in our introductory physics classrooms. Previously reported results suggesting no correlation between SE and performance in our physics classrooms led to the development of this new SE instrument. Development of the instrument, as well as field data from this pilot instrument emphasizing self-efficacy in physics (SEP) as it relates to gender, will be discussed.

Introduction

Both as former students and as instructors, we are aware of the fact that students bring to the classroom a pre-conceived set of ideas not only about physics, but also about their own abilities to do well in a physics classroom.

Self-efficacy "refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments." [1] It is context-dependent: a person can have a high SE for a given task in one context (such as a study group meeting), and a low SE for the exact same task in a different context (like a physics classroom setting). Context here does not primarily refer to the context of the science in the question, but rather the context in which the student is asked to perform. SE is also informed by previous experience, performance on similar tasks, and by vicarious experiences. [1] Correlations have been reported in other content domains between SE and performance. [2]

Little work has been conducted on students' SE in the science classroom and no research studies could be found in the literature on SE in the physics classroom, or in comparing science majors to non-science majors. As SE is believed to be strongly correlated to performance on task, this construct is of interest to us for its' explanatory power.

Locus of control is a construct related to SE, but not identical to it. [3, 4] Locus of control can best be described as a person's belief about whether her/his actions will affect later outcomes. Previously reported studies indicate that in courses frequented by science and engineering majors, there is no statistically significant difference in the locus of control scores of male and female students. [5,6]

This unexpected result raised the following research question: is there a filtering effect occurring, where students with lower SE preferentially take physics courses with less difficult math prerequisites? This led to the hypothesis that differences in physics SE will lead to differential performance, as measured by class ranking or grade, between male and female students. This hypothesis was based on patterns of female behavior often observed: female students have lower self-evaluations of their own abilities than males with same levels of demonstrated performance [7]. Therefore, the development of a SE instrument specific to the physics classroom may be especially important for female students in science, who tend to drop out of any science classroom with much better performance records than males. [7]

The Self-Efficacy in Physics (SEP) Instrument

After a review of the literature on self-efficacy, a physics classroom-specific pilot instrument was developed, consisting of eight questions. SE questions were modeled on SE questions published in other domains, and represent specific tasks seen in the context of the physics classroom, such as solving algebraic equations, word problems, and other facets of the physics classroom experience. (Table 1) Demographic and locus of control questions were also included, but are not listed here. Questions on race and sex were specifically excluded from the test design, in order to avoid invoking potential stereotype threat. [8] This information was gathered by the author from a university database. These questions, were submitted to three reviewers on campus who had expertise in SE within the context of their own disciplines, and to the PACER group. Reviews led to some refinement of the instrument, and the elimination of several questions.

Students were given a statement, and asked to agree or disagree with that statement based on a 5-point Likert scale. SE scoring was on a 1 to 5 scale, with 5 indicating the most positive response: the range of possible SE scores was 8 to 40. The eight SE questions were randomly intermixed with eight previously chosen locus of control questions.

Text of Question
I am very comfortable when I use a computer.
I can solve for the variable *r* in the expression $F = Gm_1m_2/r^2$.
I have a good intuition about how nature behaves.
I consider myself very good at math.
I have a very difficult time solving word problems.
I consider myself very poor at science.
I have a hard time using math in science classes.
I can figure out how long it will take to travel from Detroit to Chicago at 55 miles per hour.

Table 1: Self-Efficacy questions.

Field Testing

Field testing of the SEP was performed at SIUE, which has a student population of 13000, 80% of whom are undergraduates. The SEP was administered to 522 students in the 2002-2003 academic year. These students were enrolled in one of three courses: the Concepts of Physics course (N=365), a conceptual course with little mathematical background assumed; the College Physics course (N=83) populated primarily by science education and biological sciences majors, with an assumption of some familiarity with trigonometry; and the University Physics course (N=80) primarily populated by engineering majors, which assumes some calculus background. The instrument was administered mid-semester for the conceptual course, and at the end of the semester for the other two courses, attached to post-tests. The conceptual course didn't receive the SEP as a pre-and post-test due to difficulty in arranging access to these classrooms. Analysis of potential stereotype threat, as well as correlations with locus of control scores examined as a validity check, have been reported elsewhere. [9]

Conceptual Physics: Gender results

In a sample of 356 Conceptual Physics students, we found differences in the self-efficacy (SE) scores of male and female students. Male students had a higher mean score than female students. These results are consistent with the literature on male and female beliefs about their abilities to perform in the science classroom [7]. As shown in Table 2, the results are all statistically significant. However, the resulting correlation coefficients are all small. We are hesitant to attach any educational significance to this result. Weak correlations were found between class rank (performance) and SEP score, as reported elsewhere [9].

	N	$\bar{x}$	s	R	p
F	186	28.64	4.97	0.297	0.002
M	170	29.81	4.43	0.395	<0.0001
F+M	356	29.18	4.75	0.324	<0.0001

Table 2: SE for conceptual physics course

College Physics: Gender Results

Self-efficacy questions were also administered to students in the College Physics course at the end of the both semesters. This analysis, shown in Table 3, indicates that for this population there is no significant difference in responses on the SEP between male and female students.

When analyzing SE scores with respect to course performance, we find that there are sex differences. There is a statistically significant relationship between SE and course grade for female students in both semesters of this course, but not for male students, as determined by ANOVA (females N = 51, df = 4, f = 5.10, p = 0.0018; males N = 33, df = 4, f = 0.93, p = 0.4620).

	term	N	$\bar{x}$	s	$\square_E$	p
F	1	51	30.51	3.64	0.51	
M	1	33	31.52	4.18	0.73	0.247
F	2	49	30.53	3.64	0.52	
M	2	27	31.48	5.12	0.99	0.350

Table 3: SE scores for male and female students in College physics course.

University Physics: Gender Results

Self-efficacy questions were also administered to students in the 2nd semester University Physics courses. Analysis (Table 4), indicates that, for this population, there is <u>no</u> significant difference in responses between male and female students. Mean score differences are <u>not</u> in the predicted direction: female students have a higher mean score than male students. Female mean scores in this population are similar to female mean scores for the college physics population, but male mean scores differ.

	N	$\bar{x}$	s	$\square_E$	p
F	18	30.78	4.45	1.05	
M	59	29.15	6.37	0.83	0.317

Table 4: SE scores for male and female students in 2nd semester calculus-based physics course.

When analyzing SE scores with respect to course performance for the University population, there is no statistically significant relationship between grade received and SEP score, as determined by ANOVA (females N = 18, df = 4, f = 1.54, p = 0.2496; males N = 59, df = 4, f = 1.09, p = 0.3732).

Conclusions and Future Work

A pilot SE in physics (SEP) instrument has been developed for use in the physics classroom. Field-test scores indicate no difference between male and female SEP scores, but do indicate a weak correlation between end-of-term rank in course, and SEP score. [9] In the College Physics population, there is a significant difference in SEP scores when split by gender, with female students having the lower mean score. Correlation between SEP score for College Physics students and course grade is significant for female students, but not for male students. In the University Physics population, there is no difference observed in SEP scores when split by gender, and no relationship between SEP score and course grade is observed at this time. However, in all student populations, the mean score appears to be between 28.5 and 31, a very small range in which to attempt to differentiate performance.

Due to the strong correlation seen between the locus of control and SE questions, future work in developing the SEP will be done without the locus of control questions. Questions will be added to the SEP in the next version, and all questions will be validated by student interviews. Additional questions will permit us to have better discrimination, and potentially address the clustering of mean scores reported here. Further validation efforts may include administering the SEP to students immediately prior to an exam, and immediately after an exam, and examining correlations between SEP score and exam score.

Acknowledgements

I would like to thank the PACER group at SIUE for helpful suggestions and feedback. I would also like to thank Ellen Lavelle, Lynn Bartels, and Curt Lox for reviewing questions for this project.

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