

STATISTICAL AND MATHEMATICAL SELF-EFFICACY OF INCOMING STUDENTS AT A LARGE PUBLIC UNIVERSITY

Ulrike Genschel¹, Andee Kaplan¹, Alicia Carriquiry¹, Elgin Johnston², Wolfgang Kliemann²,
Kenneth Koehler¹, Ian Mouzon¹, and Hien Nguyen²

¹Department of Statistics, Iowa State University, USA

²Department of Mathematics, Iowa State University, USA

ulrike@iastate.edu, ajkaplan@iastate.edu

All participants in the ongoing STEM education discussion agree that, in addressing national priorities, a key concern is the critical transition of students from high school (or community college) to a four-year college program in the mathematical sciences in particular. Failure in college-level mathematics and statistics courses may discourage students from pursuing STEM majors or perhaps lead to complete college dropout. In fact, even a mediocre performance in these courses often restricts student career choices to fields outside of STEM disciplines. This presentation is aimed at summarizing a statistical investigation of student self-efficacy and self-confidence in mathematics and statistics, particularly with regard to gender differences. Interestingly, preliminary results indicate much higher levels of self-efficacy/-confidence in statistics compared to mathematics where differences occur. Additionally, for statistics the self-efficacy results are consistent across gender, which is seemingly not the case for mathematics.

INTRODUCTION

Many Iowa students have stated that they feel unprepared for college courses in the mathematical sciences (see for example the editorial in the Des Moines Register on April 3, 2006) and high dropout rates in initial mathematics courses taken at Iowa State University seem to substantiate this concern. In our study, close to 19% of student either drop out or fail a mathematics or statistics course in their first two semesters. Even if inadequate preparation were not a fact but merely a perception by these students, the misperception itself can have a detrimental effect on students' success (Zeldin & Pajares, 2000). This holds true in particular for women, as men have been reported to generally show higher levels of confidence regarding mathematical abilities than their female peers (see Section 2 for further discussion).

The results presented in the following are part of a larger study whose goal is to explore the STEM gender gap with focus on introductory college mathematics and statistics instruction and its association with self-efficacy instructional changes concerning factors that substantially contribute to career changes away from STEM fields, in particular for female students. As part of the study, research efforts include a detailed investigation of the self-efficacy beliefs of incoming students, i.e. first semester college students, regarding their mathematical and statistical abilities. Our data consist of the mathematical history of students from high school linked with data from a survey instrument that measures self-efficacy and mathematical self-confidence before and after basic mathematical and statistical training at Iowa State.

A Review of the Literature

Several studies have been done to gauge students' attitudes about mathematics and statistics as well as self-efficacy (see Bond, Perkins & Ramirez, 2012; Pajares & Kranzler, 1995; Shau & Emmioglu, 2012; Zeldin & Pajares, 2000; and Zeldin, Britner & Pajares, 2008). These studies have typically focused on either mathematics or statistics classes, but not both comparatively. Most of the work has been completed on a very small scale (less than 100 participants) and none with the express interest of incoming students while also considering gender, see Bond, Perkins and Ramirez (2012) and Shau and Emmioglu (2012). All STEM students encounter a mathematics or statistics course in their first two years of study; these courses therefore function as 'gate keepers,' see also Gainen (1995). For this reason, the greatest attrition among students interested in STEM fields occurs between freshman and sophomore year (Gainen, 1995). Thus the preparation level and mathematics self-efficacy of incoming students is critical to their success in STEM fields.

RESEARCH QUESTION, STUDY POPULATION AND DATA COLLECTION

Research Question

The primary research question to be answered here is: *What are the characteristics of incoming students at a large public university, such as Iowa State University?* Two groups of characteristics to be addressed are (1) the mathematical academic history of incoming students, and (2) self-efficacy and mathematical self-confidence of incoming students. In order to obtain information related to gender gap issues in STEM fields, incoming students will be grouped according to gender. The original study further considers additional groupings, which due to space constraints will not be considered here. We continue with a definition of students to be considered incoming students at Iowa State University (ISU hereafter). *Incoming Students* are defined as students who took a mathematics and/or statistics class during their very first semester enrolled at ISU and this semester also coincided with the study's survey period (Spring 2012, Fall 2012 and Spring 2013) implying that these students were asked to take the survey to measure their mathematical (statistical) self-efficacy and self-confidence during the third week of their first semester at college.

Study Population and Data Collection

The target population about which we wish to learn more consists of undergraduate students enrolled at large public universities such as Iowa State University. We obtained permission to collect student records from the institutional research board (IRB) at ISU. Students were automatically enrolled into the study if they registered for at least one introductory mathematics or statistics class at ISU during at least one of the following three semesters: Spring and Fall 2012 and Spring 2013. During each semester we implemented a survey on mathematical (statistical) self-efficacy at the beginning (*pre survey*) and at the end of the semester (*post survey*) in all lower level mathematics and statistics classes. Over the three semesters a total of 16,229 students enrolled into the study. This number excludes students who opted out of the study (32 students). From these 16,229 students we received a total of $n = 27,370$ pre and post surveys. Of the 16,299 students 4,974 can be considered *incoming* students. We obtained 2,977 pre surveys from incoming students of which 1,783 also completed a post survey at the end of the semester.

SURVEY INSTRUMENT AND STATISTICAL METHODS

We modeled the survey instrument used in this study after the *SATS-36 survey (Survey on the Attitude toward Statistics)* by Schau (1995, 2003). To adjust for the primary purpose of the study we extended the number of questions that measure students' mathematical and statistical self-efficacy and self-confidence. We will present results for a total of ten questions on self-efficacy and self-confidence labeled C1 through C10. Depending on whether the survey was given in a mathematics or in a statistics class, the questions were phrased referring either to "mathematics" - or "statistics." This is indicated in the questions by listing both options separated by a slash, i.e. mathematics/statistics.

Self-Efficacy and Self-Confidence Questions Regarding Mathematics or Statistics

- C1. I am confident that I can do the mathematics/statistics problems in this class. (reverse coded)
- C2. I expect to do well in this class. (reverse coded)
- C3. Most people can learn mathematics/statistics if they try. (reverse coded)
- C4. I just don't have a mathematical/statistical mind.
- C5. I like the challenge of solving mathematics problems. (reverse coded)
- C6. To be successful in this class I will need help from others.
- C7. Mathematical concepts are usually easy for me to understand. (reverse coded)
- C8. I will be totally lost in this class.
- C9. I am usually able to solve mathematics problems on my own. (reverse coded)
- C10. I have always been good at mathematics in school. (reverse coded)

Statistical Methods

Responses to questions were collected on a Likert scale and with possible answers of *Strongly Agree (1)*, *Agree (2)*, *Neutral (3)*, *Disagree (4)*, and *Strongly Disagree (5)*. For the purpose of the statistical analyses, positively worded questions were reverse coded and thus can be interpreted the same way as the negatively worded questions. With the implemented numerical scale, higher values indicate higher levels of self-efficacy and self-confidence. We are interested in assessing the homogeneity of the frequency distributions with respect to field of study (mathematics versus statistics) and with respect to gender (female versus male). Because of the ordinal scale of the responses we will use the Cochran-Mantel-Haenszel statistic test to assess the independence between self-efficacy and self-confidence and field of study or gender, respectively. The analyses were conducted in SAS 9.3 using the proc freq procedure.

STATISTICAL ANALYSIS AND RESULTS

In the following section we will present results for the 1,783 incoming students for which we have both pre and post survey data. We will first summarize findings for the pre-survey data and then display results for the change in self-efficacy and self-confidence over the semester, i.e. we obtain a new observation for every student that is defined as the difference in the response to a question from the pre to the post survey. Further, we begin by presenting differences in self-efficacy and self-confidence with respect to field of study, i.e. mathematics versus statistics and then continue to analyze possible gender differences within each field of study.

Summaries of Pre-Survey Data and Change in Self-Efficacy and Self-Confidence

Initial responses to questions C1—C10 provide strong statistical evidence of differences between male and female students for all questions except C2 and C8 (p-values for MH tests all below 0.0235). Further, male students express more self-confidence in their course, providing higher confidence responses with percentages between 7 and 18% above that of female students, who are more likely to express low self-confidence.

Students rarely change responses from the pre-survey to the post-survey. In fact no more than 7.66% of students reported a change in self-efficacy/confidence of more than one Likert-scale point for questions C1—C10.

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
3.67%	7.66%	5.32%	4.98%	4.15%	6.41%	3.11%	6.8%	3.42%	2.9%

Table 1: Percent of students reporting a change in self-efficacy of more than one Likert-scale point.

Mathematical Versus Statistical Self-Efficacy and Self-Confidence

For the group of incoming students under consideration we found no statistically significant differences in the frequency distributions between students enrolled in mathematics classes and students enrolled in statistics courses for questions C1—C3, C5, C7—C9; corresponding p-values ranged from p-value=0.1323 to p-value=0.7928 with df=1 for the Cochran-Mantel-Haenszel Chi-square test statistic M. Significant differences were found, however, for questions C4 (p-value < 0.0001, df=1, M=29.92) and C6 (p-value=0.0003, df=1, M=13.08). Question C10 yielded a p-value of 0.0752 (df=1, M=3.17), which we interpret as weak-moderate significance because we expect an increased chance of a Type I error due to the fairly large number of significance tests conducted as part of the analysis.

Interestingly, preliminary results indicate higher levels of self-efficacy/-confidence in statistics compared to mathematics within those questions that showed a difference at all. Additionally, for statistics the levels of self-efficacy/confidence are consistent across gender, which is seemingly not the case for mathematics. For instance students taking a course in mathematics responding to C6, the difference in responses between male and female students is significant (p-value = .0488, df=1, M = 3.88) with 16.57% of male students, but only 12.79% of female students disagreeing or strongly disagreeing. There is no statistical difference between male and female students in statistics courses on C6 (p-value = 0.0722, df=1, M = 3.23).

CONCLUSION

Many students struggle in college courses that emphasize mathematics. But even before the courses begin female students express less confidence than their male counterparts, a feature more pronounced in mathematics courses than statistics courses. Further, while students do reevaluate their efficacy over the semester, they seldom have strong changes in their evaluation, indicating that male students remain more confident in their abilities going forward academically. The fact that female students begin college with less self-confidence in mathematics combined with students' tendency to keep consistent views of their ability to succeed in mathematically intensive courses may contribute to the STEM gender gap.

Blickenstaff (2005) claims that the under-representation of females in STEM careers and majors cannot be viewed as being caused by a single issue, but rather the factors that allow women to leave STEM fields must be seen as layers contributing to the problem. Due to space constraints we have focused only on one aspect, self-efficacy/confidence in mathematics and statistics, however our further work aims to address the multiple facets behind the disparity seen between genders in STEM.

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