

## Gender-based Analysis of Learning Outcomes in Inquiry-Oriented Linear Algebra

Brooke Athey, Matthew Mauntel, Muhammad Haider, and Christine Andrews-Larson  
Florida State University

*In order to better understand gender-based differences in learning experiences and outcomes in inquiry-oriented instructional settings, we analyze data from a common end-of-term assessment administered across 7 sections of linear algebra. This analysis focuses on data from 58 students, 22 of whom identified as female and 36 of whom identified as male. Distribution of the 58 students' scores was negatively skewed, similar to that of broader sample of 153 assessment scores (many of which did not have gender information available as that was collected separately from the assessment). A two-tailed t-test with independent samples was administered, revealing that the difference between the scores of the two groups is not statistically significant.*

*Key words:* inquiry-oriented instruction, learning outcomes, gender

Some research suggests that inquiry-based approaches to teaching undergraduate mathematics are likely to “[level] the playing field” between men and women (Laursen, Hassi, Kogan, & Weston, 2014, p. 412). Other research suggests that inquiry-oriented approaches may disproportionately advantage men (Johnson, Andrews-Larson, Keene, Keller, Fortune, & Melhuish, 2017). Inquiry-oriented instruction aims to support students in ‘reinventing’ important mathematical ideas by first posing challenging problems to students. The instructor’s role is to elicit and build on these ideas so as to support the development of more formal language and notation that is rooted in students’ initial, informal, and intuitive ideas (Rasmussen & Kwon, 2007). In our study, we ask: Are there gender-based difference in learning outcomes among students whose instructors received support to teach inquiry-oriented linear algebra?

Assessment data was collected from 153 students at the end of the term from 7 different classes; instructors of these classes received supports (curricular materials, a 16-hour summer workshop, and facilitated online workgroups for one hour per week during the semester of instruction) to teach inquiry-oriented linear algebra. The assessment consisted of 9 items, including both multiple choice and open-ended response questions, aimed to measure student understanding of key ideas in introductory linear algebra (solutions to linear systems, linear transformations, span and linear independence, and eigenvectors and eigenvalues). We were only able to match 58 of these assessments with gender data gathered as part of a student survey. Of those students, 22 identified as female and 36 identified as male. A team of 3 coders developed and used a rubric for scoring the open-ended assessment questions. After fine-tuning of the rubrics, 13% of the assessments were double coded, with each item requiring at least 80% inter-rater reliability (mean of 91%). Mean scores and standard deviations were computed for students who identified as male and as female; students who identified as other were omitted from this analysis. A two-tailed t-test with independent samples was conducted to determine if the difference of means of male and female TIMES students was statistically significant.

There is not a statistically significant difference between the scores of students who identified as male and female. With 51 points possible, the mean was 38.09 (SD=7.30) for female students and 38.59 (SD=7.67) for male students. There was not a significant effect for gender,  $t(57) = .248$ ,  $p = .805$ . The effect size between male and female students was .065. A larger sample size is needed to support bolder claims about the generalizability of this finding.

## References

- Johnson, E., Andrews-Larson, C., Keene, K., Keller, R., Fortune, N., & Melhuish, K. (2017). *Inquiry and Gender Equity in the Undergraduate Mathematics Classroom: Not a Silver Bullet*. Manuscript submitted for publication.
- Laursen, S. L., Hassi, M. L., Kogan, M., & Weston, T. J. (2014). Benefits for women and men of inquiry-based learning in college mathematics: A multi-institution study. *Journal for Research in Mathematics Education*, 45(4), 406-418.
- Rasmussen, C., & Kwon, O. N. (2007). An inquiry-oriented approach to undergraduate mathematics. *The Journal of Mathematical Behavior*, 26(3), 189-194.