

Additional benefits of spatial-visualization skills workshops: assessing improvements in student self-efficacy and other affective skills.

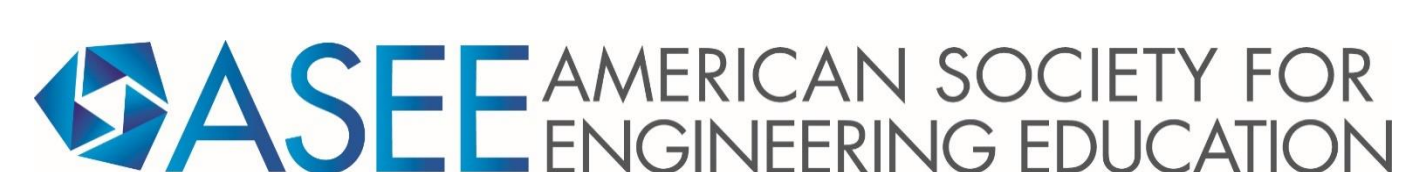
Dr. Alexander John De Rosa, Stevens Institute of Technology (School of Engineering and Science)

Alexander De Rosa is a Teaching Assistant Professor in Mechanical Engineering at Stevens Institute of Technology. Alex specializes in teaching in the thermal-fluid sciences and has a background in experimental combustion. He gained his PhD in 2015 from The Pennsylvania State University in this area.

Dr. Maxine Fontaine, Stevens Institute of Technology (School of Engineering and Science)

Maxine Fontaine is a Teaching Assistant Professor in Mechanical Engineering at Stevens Institute of Technology. She received her Ph.D. in 2010 from Aalborg University in Aalborg, Denmark. Maxine has a background in the biomechanics of human movement, and she currently teaches several undergraduate courses in engineering mechanics. Her research interests are focused on improving engineering pedagogy and increasing diversity in engineering.

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Alexander J. De Rosa & Maxine Fontaine

Stevens Institute of Technology



Introduction

Spatial visualization skills (SVS) are critical to success in STEM. These skills have been correlated with high-level problem-solving ability, particularly in science and mathematics. Numerous studies have shown that higher levels of spatial skills are displayed by students who are more successful in STEM fields and who are retained at higher rates in college [1].

Given their importance to success and retention, it is surprising that spatial skills are rarely taught explicitly. Instead they are often developed through life experiences, such as playing with certain toys and through sports. This reliance on experiential learning leads to significant gender differences in spatial skills between men and women and also with underrepresented groups (URM), with women and URM typically displaying lower levels of spatial ability than their white male colleagues.

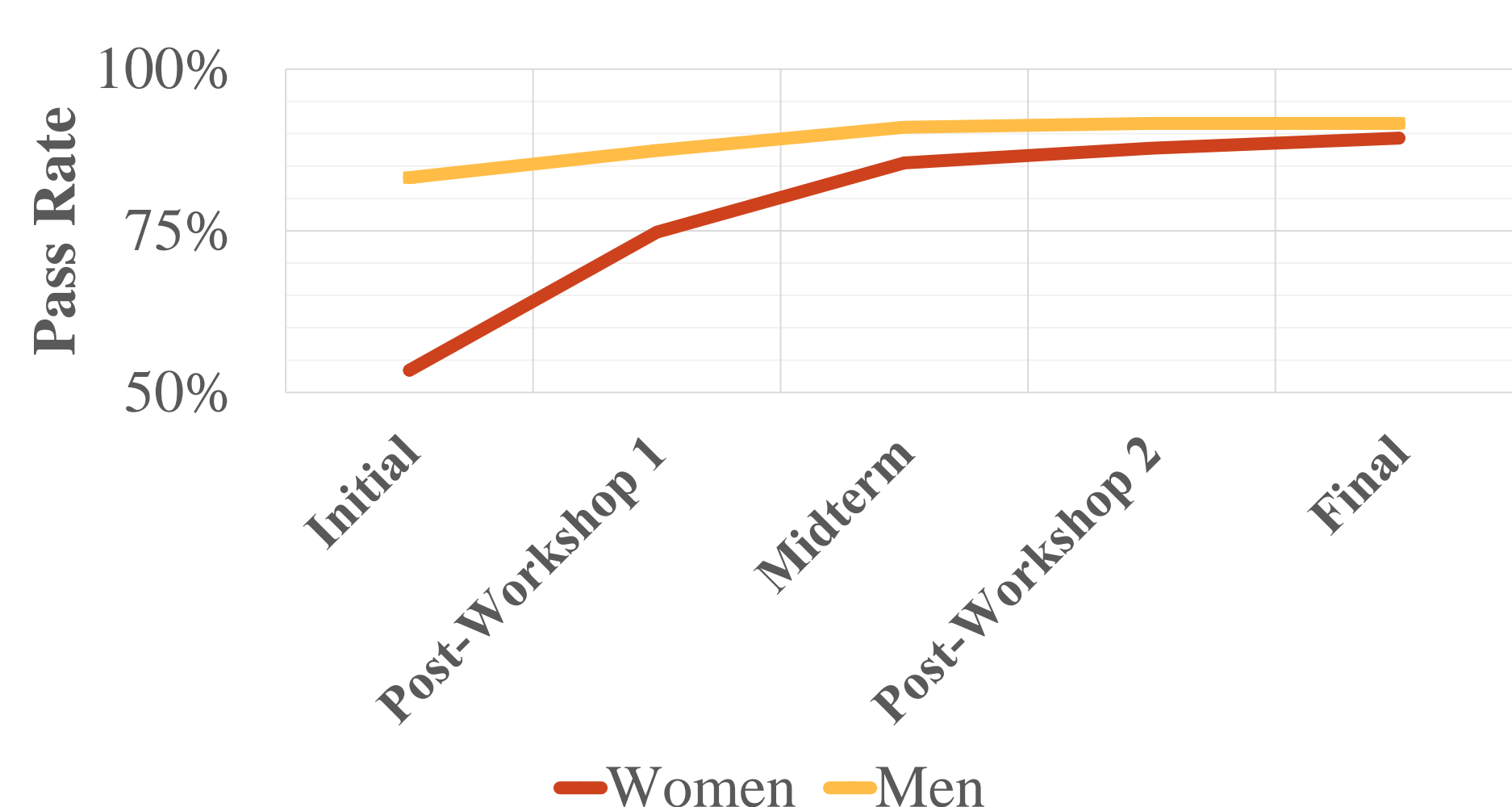


Figure 1. Overall PSVT:R pass rates for women and men over the course of the semester. [2]

In recent years, various courses have been developed to train students in spatial skills. At Stevens, a voluntary spatial skills workshop, based on the model developed at CU Boulder, was initially implemented in a first-year graphics course in 2016 using the PSVT:R to measure spatial ability [2]. As shown in Fig.1, the workshop was successful in improving the spatial ability of students and continues to be implemented as part of the first-year graphics course.

An interesting result from this implementation was that students who did not complete the workshop also showed a significant improvement in spatial ability after completion of the graphics class. This improvement is detailed in Fig.2.

The question was then asked, if the workshop and class are both effective in improving spatial ability, are there ancillary benefits to the students such as community building, and the development of affective skills, that make the increased costs of implementing the workshop worthwhile?

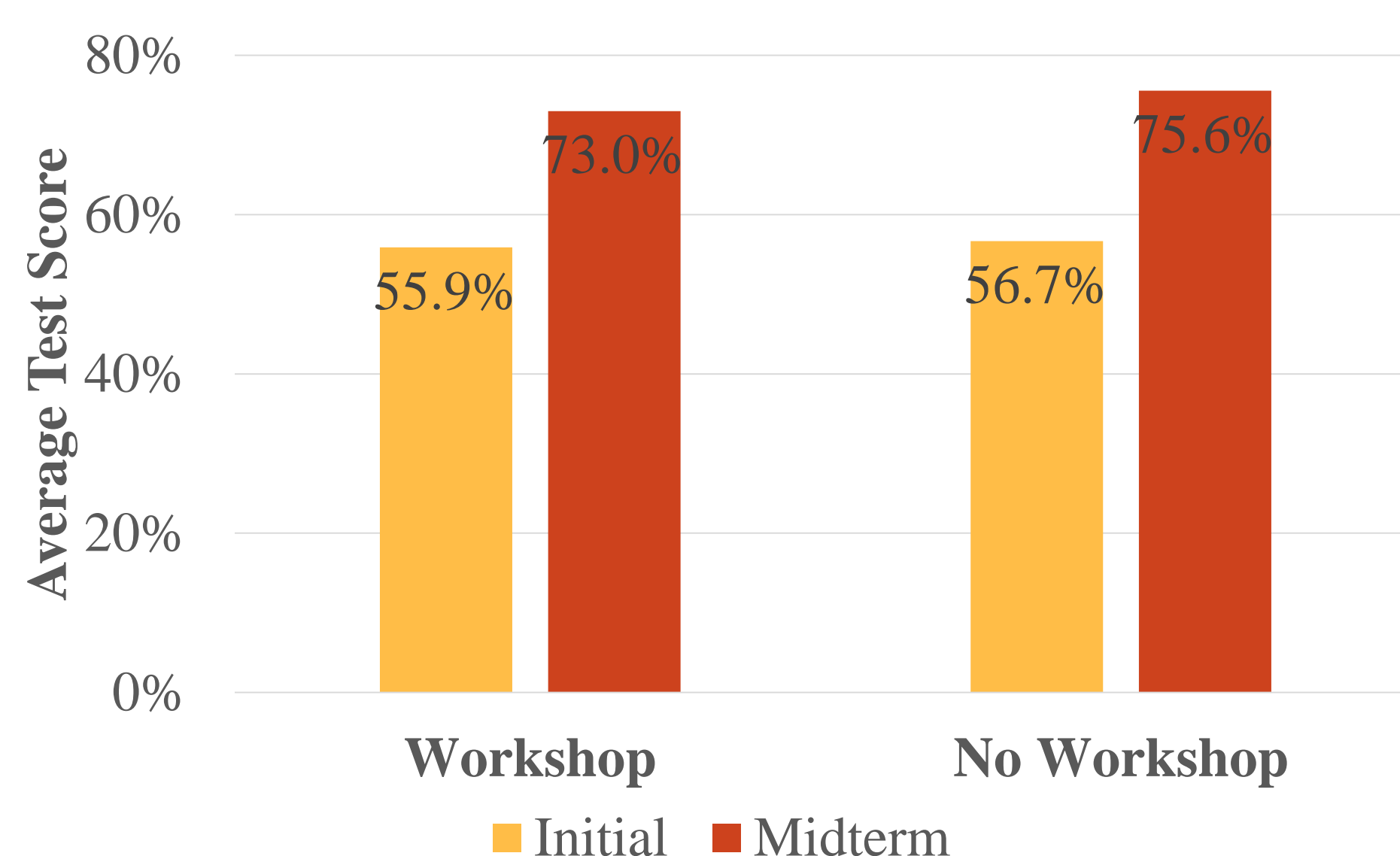


Figure 2. Comparison of average PSVT:R test scores at the start and middle of the semester for students who completed the first workshop session, and did not complete the first workshop session.

Methodology

To answer this question, student affective skills were measured pre- and post- workshop using the "Self-Efficacy Formative Questionnaire" developed by Erickson & Noonan [3]. The survey comprises 13 questions concerning how students view their personal abilities and whether their ability is malleable and grows with effort. Students rank their own scores in these questions on a scale from 1-5. Students also completed a separate post-workshop survey concerning their perceptions of the workshops and related educational activities in a similar fashion to typical student end of course surveys.

For further information on the workshop format and activities as they relate to the spatial skills component see [2].

Results & Discussion

Results are shown for a pilot investigation implemented as part of the 2019 summer bridge programming for incoming students at Stevens. As part of this program, 19 incoming freshmen from underrepresented and low-income groups completed the SVS workshop and associated surveys.

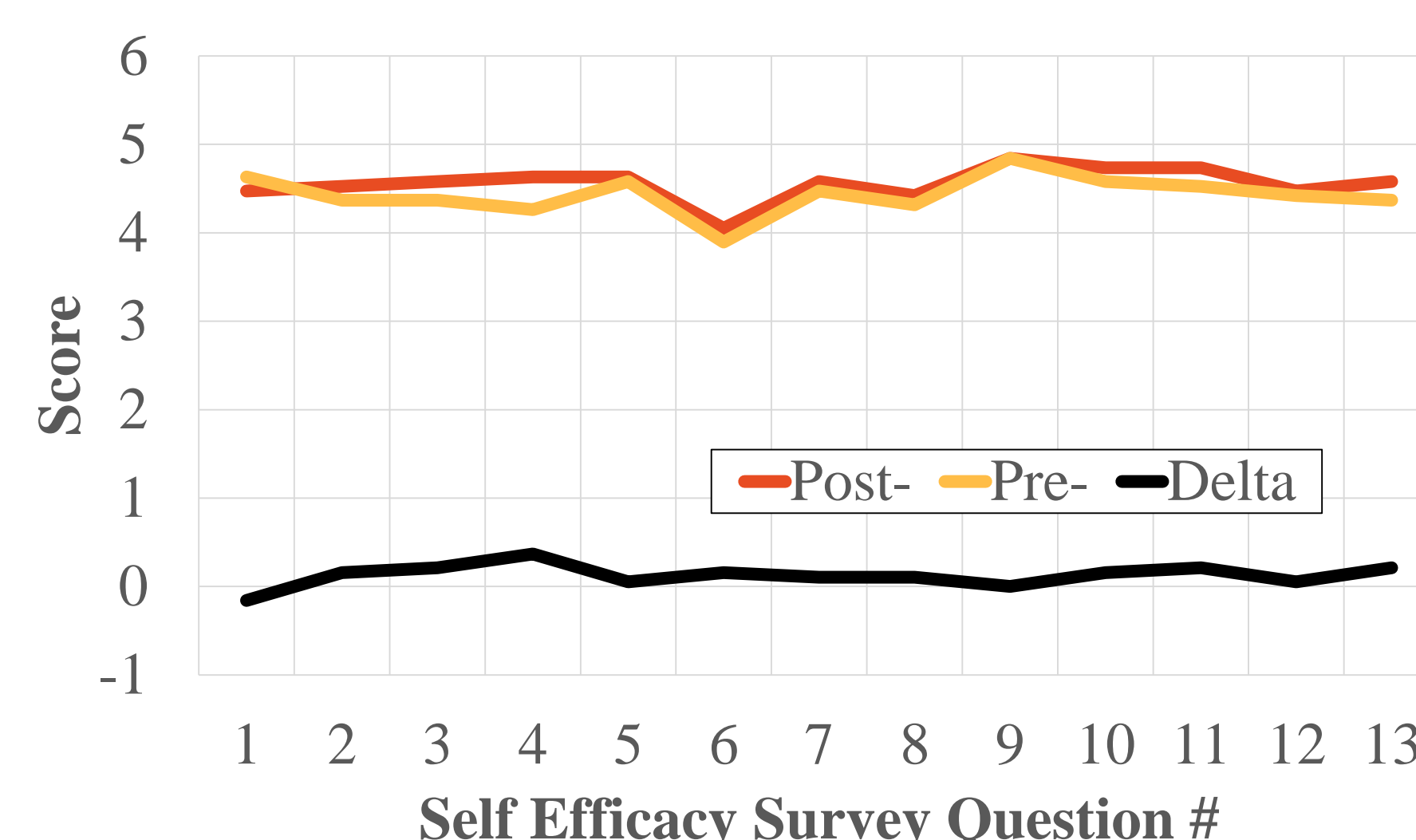


Figure 3. Student responses to the self-efficacy survey pre- and post-workshop

A comparison of student pre- and post-workshop responses to the self-efficacy survey indicated little change in student affective skills as evidenced in Fig.3. While there was a modest increase in student affective skills, with an overall average increase in student scores of 2.5% (0.13) observed, the small sample size prohibits further conclusions being drawn or correlation between students scores and other data being made in a meaningful manner.

In terms of the end-of-course evaluations, two students did make comments indicating that they enjoyed the communal nature of the workshops and the chance to engage with their peers but no other students highlighted this potential benefit of the workshop.

Future Work

In order to increase the available dataset, this investigation is currently being implemented as part of the 2019 fall graphics classes at Stevens. A total of 133 students are involved in the SVS workshops and as such a much larger dataset is being generated that encompasses a more diverse student population. Future plans also include correlating workshop outcomes with related student performance indicators such as GPA and scores in related courses.

References

1. Sorby, S., (2009) "Educational Research in Developing 3-D Spatial Skills for Engineering Students," International Journal of Science Education, vol. 31, no. 3, pp. 459-480, 2009.
2. Fontaine, M., & De Rosa, A.J., (2019). "A First-Year Engineering Spatial Skills Workshop: Implementation, Effectiveness, and Gender Differences" Proceedings of the 2019 ASEE CoNECD, Crystal City, VA. #24792.Gaumer
3. Erickson, A.S. & Noonan, P.M. (2018). "Self-efficacy formative questionnaire" In The Skills That Matter: Teaching interpersonal and intrapersonal competencies in any classroom (pp. 175-176). Thousand Oaks, CA: Corwin.