Impact of Visualization Training on Student Leaving

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Abstract

The ability to mentally rotate three-dimensional objects has been shown to be an important skill predictive of success in engineering. In particular, spatial skills are important to success in engineering graphics and to success in the ability to successfully learn how to use computer aided design software. Significant gender differences, favoring males, in mental rotation ability have been found by many researchers through the years. Recent data also suggests that the spatial skills of students from underrepresented minorities, especially African Americans, lag behind those of their majority counterparts. Spatial skill remediation at the university level has led to improved retention and higher grades for engineering students, particularly for women. In previous studies, performance in engineering programs has been examined, comparing students who participated in the training with those who didn't. This paper examines the impact of spatial skills training for students who left mechanical engineering. Results will be presented by gender.

Introduction

The authors have been involved in a course for developing 3-D spatial skills since 1993 and their work has been supported by the National Science Foundation in the US for more than $1.5M over that period. Beginning in 1993, first year engineering students have been tested with the Purdue Spatial Visualization Test: Rotations (PSVT:R, Guay, 1977) during orientation, just prior to the start of fall semester. In the initial years, students declaring a major of mechanical, civil, environmental, or general engineering were administered the test; since 2000 students in all engineering majors took the test. A sample problem from the PSVTR: is shown in Figure 1.

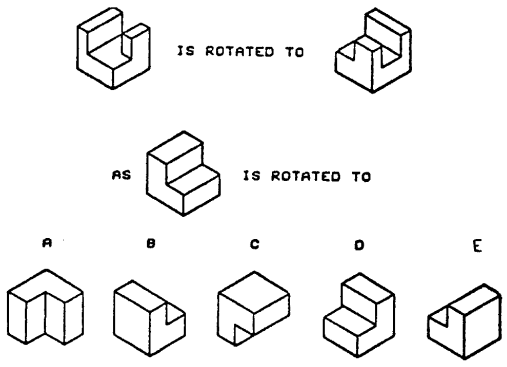

Figure 1. Sample Problem from PSVT:R

Through this work, an extensive database has been compiled that includes pre-test scores on the PSVT:R for more than 11,000 first-year engineering students. The data from this database has been used to conduct several retrospective longitudinal studies over the years. Most of these studies have focused on the students who *remained* either in engineering or at Michigan Tech. In these previous longitudinal studies, it has been shown that for students who initially exhibit poorly developed 3-D spatial skills, improvements in course grades and in engineering retention can be achieved through the spatial skills intervention (Sorby, 2001; Sorby, 2005; Veurink & Sorby, 2011). In particular:

- Spatial skills training appears to have a significant, positive impact on grades in several introductory courses including Calculus, Chemistry, Physics, and Computer Science as well as a variety of introductory engineering and/or graphics courses. In these previous longitudinal studies, only the first grade achieved was considered in the analysis.
- Spatial skills training appears to have a significant, positive impact on retention both within engineering and at the university, particularly for women.

In this study, we have examined transcripts for students who were not retained to determine if there is a difference between those who received spatial skills training and those who did not. Analysis of the performance of the "leavers" will enable us to form a clearer picture of the impact of the spatial skills training on student success and retention.

Method

Since 1993, first-year engineering students at Michigan Tech have taken the PSVT:R (Guay, 1977) during orientation the week prior to the start of the fall semester. In 1993, a random sample of students who failed the exam was selected for participation in the spatial skills course. From 1994-2008, students who failed the PSVT:R with a score of 60% or lower during orientation were encouraged to enroll in the spatial skills training course. Some chose to do so; others did not. Beginning in 2009, students who score 60% or lower are now required to enroll in the spatial skills course.

For the current study, transcripts of students who matriculated in the fall of 1996, 1997, 1998, 2000, 2001 and 2002 were obtained for those students who scored **70%** or lower on the PSVT:R. In addition, only students with a declared major of Mechanical Engineering (ME) were considered. This group included a few students who initially declared "General Engineering" but who later went on to declare ME as their intended major. The rationale for selecting only ME students was that during the 1996-1998 timeframe, ME was one of the few engineering disciplines at Michigan Tech with a required graphics sequence of courses. After 2000, all engineering students were required to enroll in a common first-year engineering program which has a graphics component.

The transcripts were further subdivided into four groups: 1) those who completed an ME degree, 2) those who completed a STEM degree other than ME at Michigan Tech, 2) those who completed a non-STEM degree at Michigan Tech, and 4) those who left Michigan Tech without receiving any degree. Transcripts were also sorted into an Experimental Group (EG), i.e., those who initially scored 60% or lower on the PSVT:R and chose to take the spatial skills course and a Comparison Group (CG), i.e., those who initially scored 70% or lower on the PSVT:R. It should be noted that the CG

consists of students who chose not to enroll in the spatial skills course as well as those who scored marginally well on the PSVT:R and were not invited to take the spatial skills course.

No significant differences, other than those already reported by the authors in previous papers, were found between the two groups who completed their ME degrees. The remainder of this paper will focus on the students in the three remaining groups, the ME "leavers." Since previous studies have shown the importance of spatial skills training for the success of women, this analysis will be presented by gender.

Results

For the leavers who stayed at Michigan Tech and completed a STEM degree, some interesting differences between men and women were obtained. It should be noted that the projected reasons for students' leaving were through transcript analysis only; no direct interviews with the students were performed. Table 1 includes the findings from this analysis.

Table 1. Leavers who Remained at Michigan Tech and Completed a STEM Degree

	Females	Males
Experimental Group	• Good grades, but switched to a different engineering field (n=3)	• Had trouble with multiple courses, primarily math and/or physics, and switched to Mechanical Engineering Technology (n=4) or Forestry (n=1)
Comparison Group	• Good grades, but switched to a different engineering field (n=2) • Had trouble with multiple courses, primarily math and some graphics, and switched to Mechanical Engineering Technology (n=2) or Biology (n=1)	• Good grades but switched to a different engineering field (n=3), Mechanical Engineering Technology (n=1), or Biology (n=1) • Had trouble with multiple courses, primarily math and some graphics, and switched to Mechanical Engineering Technology (n=7) • Had trouble with multiple courses, primarily math and physics, and switched to a different engineering field (n=1) or Wildlife Ecology (n=1)

For the leavers who remained at Michigan Tech and received a non-STEM degree (primarily in Business), they typically had multiple failures in mathematics and other science courses before switching to a less "math intensive" field. Most appeared to give the ME curriculum an honest effort, switching out of the field after an average of about two years of trying. In fact, one student switched at the end of six quarters when he had only succeeded in completing Calculus I with a D grade at that time. There were 7 males and two females in this group. The only female in the experimental group in this category had good grades in the ME curriculum but switched to Scientific and Technical Communication.

For the leavers who left Michigan Tech without completing any degree, interesting patterns by gender are also apparent. Table 2 presents the results from this analysis.

Table 2. Leavers who did not Complete a Michigan Tech Degree

	Females	Males
Experimental Group	• Left after three or more years. Successful completion of introductory courses but multiple failures in upper division ME courses (n=2) • Left after two years. GPA acceptable, but decreased each semester in attendance. (n=1)	• Left after three or more years. Successful completion of introductory courses but multiple failures in upper division ME courses (n=1) • Had trouble with multiple courses, primarily math, and some graphics (n=4) • No apparent reason (n=3)
Comparison Group	• Had trouble with multiple courses, primarily math and some graphics (n=9) [One student in this category had failures in only graphics] • No apparent reason (n=2)	• Had trouble with multiple courses, primarily math, and some graphics (n=27) • No apparent reason (n=8)

Discussion

When comparing the students who left ME but graduated with STEM degrees, the females who received spatial training appeared to have less difficulty in their curriculums than the males. All of the females in the Experimental Group had good grades, while the majority of the males and females in the Comparison Group and all of the males in the Experimental Group struggled in multiple classes. Although there was only one female in the Experimental Group who graduated with a non-STEM degree, she completed her STEM classes without significant difficulty while all others in this group struggled with STEM classes before changing programs. It seems likely that this one female student merely lost interest in mechanical engineering.

Females in the Experimental Group who did not complete a Michigan Tech degree appeared to leave Michigan Tech as they started their upper division work and struggled with it while some of the males in the Experimental Group and some of both the males and the females in the Comparison Group left Michigan Tech even though they did not appear to be struggling with their courses. This suggests that spatial training has a positive impact on retaining females within engineering, at least through the early critical years in the curriculum.

The males in the Experimental Groups had similar struggles as males and females in the Comparison Groups even though the Comparison Groups consisted of students with PSVT:R scores 70% and below while the Experimental Group consisted of students with PSVT:R scores of 60% and below. The patterns of leaving for the males in the experimental group are similar to those for the males and females in the control group; whereas, the patterns for females in the experimental group are significantly different than those in the other groups.

Conclusions

This study appears to shed light on why spatial training has a higher impact on the retention of females than males at the University. The females in this study who took the spatial training course appear to be leaving the university only if they are not successful in the latter stages of an engineering curriculum, while males taking the spatial training course appear to leave the university for a variety of reasons, primarily through struggles with introductory courses. Both males and females in the control group typically left for poor performance, but not always. The mitigating effects of the spatial skills training appears to help the young women successfully complete their introductory courses at a higher rate and either stay in STEM fields or stay at the university.

References

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