Engineering Design Graphics Journal (EDGJ)
Fall 2012, Vol. 76, No. 3
http://www.edgj.org

ISSN: 1949-9167

Comparison of Spatial Skills of Students Entering Different Engineering Majors

N. Veurink
Michigan Technological University

S. A. Sorby
The Ohio State University

Introduction

Spatial skills have been shown to be important to success in an engineering curriculum, and some question if poor spatial skills prevent students from entering STEM fields or if students with weak spatial skills avoid engineering disciplines believed to highly spatially-oriented. Towle et al., (2005) found that an engineering student's score on a spatial task was directly correlated with their belief in their ability to complete the task. Betz and Hacket (1981) found that a person's self efficacy was related to their career choice processes and that there was a lack of complete correspondence between a student's perception of ability and measured ability to successfully pursue various careers. They also found that males equally believed in their abilities to succeed in both traditional and non-traditionally male occupations while females had a lower self-efficacy in their abilities to succeed in traditionally male careers such as mathematics and engineering than in their abilities to succeed in traditionally female careers. Veurink and Hamlin (2011) found that freshmen students entering engineering disciplines that are perceived as more spatially oriented such as mechanical engineering had higher averages on a spatial test than students entering engineering disciplines that are perceived as less spatially oriented such as environmental engineering. However, in the 2011 Veurink and Hamlin study, the numbers of students in some of the engineering majors were quite low. This study builds on the previous study by comparing spatial test scores of freshmen engineering students over a 14-year time period.

Since 1993, Michigan Tech has given freshmen engineering students the Purdue Spatial Visualization Test: Rotations (PSVT:R) (Guay, 1977) in order to identify students with low spatial skills as potential candidates for a spatial training course. From 1993 to 1999 primarily Mechanical, Civil, Environmental, Biomedical and Geological engineers were administered the PSVT:R. From 2000 on, all engineering majors were given the spatial test. This study compares the PSVT:R scores by engineering discipline, and by gender in each discipline, of Michigan Tech freshmen engineering students who matriculated between 1996 and 2009.

ISSN: 1949-9167

Results

Table 1 compares the average PSVT:R and Math ACT scores for freshmen engineering students by major. The math ACT scores are shown as a study conducted by Parolini (1994) showed there is a link between math ACT and PSVT:R scores. For this study, a correlation of 0.35 was found between PSVT:R and Math ACT scores for all students, and this correlation was highly significant ($p < 0.0001$). Students in Environmental and Geological Engineering have the lowest average PSVT:R scores, while students in Electrical, Computer, and Mechanical Engineering have the highest average scores. The table also shows that although the Environmental Engineering students have the lowest average PSVT:R score, they do not have the lowest average Math ACT score. Nor do the Mechanical Engineering students, with the highest average PSVT:R score, have the highest average Math ACT score.

Table 1. Comparison of average student PSVT:R score out of 30 possible points by engineering major.

Major	Average PSVT:R Score	Average Math ACT score
Environmental	21.7 (n=366)	27.0 (n = 340)
Geological and Mining	21.8 (n=102)	26.3 (n=96)
Biomedical	22.3 (n=544)	27.9 (n=515)
Chemical	23.3 (n=730)	28.4 (n=711)
Civil	23.4 (n=980)	26.8 (n=951)
Undecided	23.4 (n=2260)	26.4 (n=2179)
Materials	23.8 (n=124)	28.3 (n=114)
Electrical	24.0 (n=718)	27.6 (n=658)
Computer	24.2 (n=641)	27.9 (n=590)
Mechanical	24.4 (n=2969)	27.3 (n=2855)

Since some of the engineering disciplines have a higher percentage of females than other disciplines, and studies have shown that females often have less-developed spatial skills compared to males, Tables 2 and 3 break the above comparison down by gender and show where there are significant differences in the PSVT:R scores among

ISSN: 1949-9167

the engineering majors. Correlations between PSVT:R score and Math ACT score were also found for the two gender groups. The correlation between PSVT:R score and Math ACT score was 0.432 for females and 0.35 for males. Both correlations were highly significant ($p<0.0001$).

Table 2. Comparison of average *male* student PSVT:R score out of 30 possible points by engineering major.

Major	Average PSVT:R Score	PSVT:R scores significantly different than Materials students?	Average Math ACT score	Math ACT scores significantly different than Materials students?
Geological and Mining (GEO)	23.3 n=68 s=5.15	Yes	26.9 n=64	Yes
Environmental (ENV)	23.6 n=184 s=4.35	Yes	26.7 n=171	Yes
Biomedical	23.8 n=283 s=4.47	Yes	28.0 n=268	Yes
Civil	23.9 n=794 s=4.41	Yes	26.8 n=771	Yes
Undecided (EUN)	24.1 n=1867 s=4.20	Yes	26.3 n=1799	Yes
Chemical (CHEME)	24.3 n=519 s=4.15	No	28.5 n=505	No
Electrical (EE)	24.4 n=651 s=4.42	No	27.7 n=597	Yes
Computer (COMP)	24.5 n=602 s=4.28	No	28.0 n=557	Yes
Mechanical (ME)	24.7 n=2704 s=3.85	No	27.4 n=2598	Yes
Materials (MSE)	25.0 n=93 s=4.27		28.8 n=86	

ISSN: 1949-9167

Table 3. Comparison of average *female* student PSVT:R score out of 30 possible points by engineering major.

Major	Average PSVT:R Score	PSVT:R scores significantly different than Civil students?	Average Math ACT score	Math ACT scores significantly different than Civil students?
Geological and Mining (GEO)	18.9 n=34 s=4.60	Yes	25.0 n=32	Yes
Environmental (ENV)	19.8 n=182 s=4.60	Yes	27.3 n=169	No
Computer (COMP)	19.8 n=39 s=5.94	Yes	26.3 n=33	No
Materials (MSE)	20.2 n=31 s=5.46	No	26.8 n=28	No
Undecided (EUN)	20.2 n=393 s=5.48	Yes	26.5 n=380	No
Electrical (EE)	20.3 n=67 s=5.67	No	26.9 n=61	No
Biomedical	20.7 n=261 s=4.75	No	27.8 n=247	Yes
Chemical (CHEME)	20.7 n=211 s=4.58	No	28.1 n=206	Yes
Mechanical (ME)	21.0 n=265 s=4.93	No	27.0 n=257	No
Civil	21.3 n=186 s=4.56		26.9 n=180	

Discussion

Mechanical and civil engineering are typically considered to be highly visual engineering fields, and the above data show that males in Mechanical Engineering have the second highest average PSVT:R score of the males. Females in Civil Engineering have the highest spatial skills, while females in Mechanical Engineering have the second highest average PSVT:R score of the females. Electrical, Computer, and Environmental Engineering are often considered to be less visually oriented than other engineering disciplines, and females in those disciplines do have lower PSVT:R scores than females

ISSN: 1949-9167

in all other disciplines except Materials Engineering and those undecided on an engineering major. Male Environmental Engineering students have the second lowest PSVT:R scores of the males.

The greatest differences between the males and the females are that females in Civil Engineering appear to have stronger spatial skills than females in all other engineering disciplines while males in Civil Engineering have the fourth lowest average PSVT:R score of the males. Female Materials Science and Engineering students have the fourth-lowest PSVT:R scores of the females, while the male MSE students have the highest PSVT:R average of the males.

In general, for both males and females, the students in engineering majors with lower PSVT:R scores also had lower Math ACT scores, although exceptions did occur. These exceptions and the correlations found between Math ACT and PSVT:R scores show that other factors contribute to spatial ability. However, this correlation could explain why male Electrical and Computer Engineering students had higher PSVT:R scores than males in disciplines considered to be more visually oriented.

It should be noted that the scores reported here are for first-year engineering students who completed the test before enrolling in any college courses. They are not really "mechanical engineers" per se, since they graduated from high school only three months prior to taking the test. So, in reality, this study attempts to measure whether students with high spatial ability are *attracted* to fields where high spatial ability is a requirement. Thus it appears that for women, well-developed spatial skills are particularly important in order to be attracted to fields which are perceived to be highly spatial (civil and mechanical); whereas, for men, this does not seem to be as critical. What is interesting is that the students going into Geological Engineering, both male and female, have the weakest spatial skills. Geological Engineering is one of the most highly demanding spatial career options, yet it is unclear that students understand the spatial demands they will face as geological engineers.

Another factor that could be contributing to the fact that students who declare Mechanical Engineering as their major seem to have higher PSVT:R scores than students who declare other engineering majors could be that these students engaged in activities as children thought to help develop skills more frequently than did students who expressed an interest in other, less spatially demanding, engineering fields. For example, taking mechanical drafting and CAD courses in middle and high school has been shown to predict better developed spatial skills, and it could be that students interested in Mechanical Engineering have participated in these courses at a higher rate than those who declare a major of geological or environmental engineering.

Conclusions

Through this data analysis, it is apparent that people with higher spatial ability are typically attracted to spatially demanding careers. What is not clear is whether helping

ISSN: 1949-9167

students improve their spatial skills at an earlier age will also lead to increased enrollment, especially for young women, into these spatially demanding fields. It should also be noted that even though the spatial skills of students who declare, for example, environmental engineering as a major are lower than those who declare mechanical engineering, the spatial skills are likely still higher than those who would declare psychology as a college major. All engineering fields are spatially demanding and students in all engineering disciplines require well-developed spatial skills—it just appears that some disciplines are more spatially demanding than others.

References

Betz, N.E. and Hackett, G (1981*). The relationship of career-related self-efficacy expectations to perceived career options in college women and men*, Journal of Counseling Psychology, 28(5), 399-410.

Guay, R. B. (1977*). Purdue spatial visualization test: Rotations*, West Lafayette, IN, Purdue Research Foundation.

Parolini, L.L. (1994). *Gender Differences on Predictors of Success on the Purdue Spatial Visualization Test:Rotations,* Master's Thesis, Michigan Technological University.

Towle, E., Mann, J., Kinsey, B., O'Brien, E. J. , Bauer, C. F., & Champoux, R. (2005). *Assessing the Self Efficacy and Spatial Ability of Engineering Students from Multiple Disciplines,* Proceedings from ASEE/IEEE Frontiers in Education Conference Indianapolis, IN, S2C-15-S2C19.

Veurink, N. and Hamlin, A.J. (2011). *Spatial Visualization Skills: Impact on Confidence in an Engineering Curriculum*, Proceedings of the 2011 ASEE Annual Conference & Exposition, Vancouver, BC, 2011.

Dr. Veurink can be reached at norma@mtu.edu, Dr. Sorby can be reached at sorby.1@osu.edu