Using the Purdue Spatial Visualization Test to Predict Success in Statics

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Abstract

There has been considerable research concerning the relationship between spatial visualization skills and success in engineering studies. These studies have looked at gender differences in spatial visualization ability (using various tests such as the Purdue Spatial Visualization Test, PSVT) and the correlation between this ability and (usually) engineering graphics. This paper is an interim report concerning an ongoing study at North Dakota State University to replicate the results of the literature with special regards to skills in the first course in vector mechanics, statics. Preliminary findings show a very weak correlation between the PSVT and success in statics, which would seen to indicate that success on the PSVT is not a good predictor of success in this course.

I. Introduction

There is certainly an incentive to discover basic skills that can improve learning in engineering courses. Engineering programs suffer from high drop-out rates, especially among female students.[1] Many researchers have studied this extensively. Sorby Baartmans at Michigan Technological University sought to identify and improve spatial visualization skills among female engineering students.[2] A recent paper chronicles the success of a course designed to improve spatial visualization skills.[3] They have found considerable success in improving these skills in both men and women, though the women, who on the average start out with lower skills, realize greater improvement. Gimmestad studied gender differences in spatial visualization and success in engineering design courses, finding weaker visualization skills among female students.[4] In a more general approach, Peters, Chisholm, and Laeng studied the correlation between spatial ability and general academic success, also dealing with gender.[5]

Other researchers have investigated ways spatial visualization skills effect success in various courses. The most obvious of these are courses dealing in engineering graphics. Hsi, Linn, and Bello, conducted a five-year study in how improving spatial visualization and reasoning skills effected engineering graphics.[6] The correlation was low ($r = 0.35$) but statistically significant ($p < 0.05$). A similar study was done by Pleck, *et. al.*[7]

Another group of researchers has examined the causes of differences in spatial visualization skills. For example, Deno looked into how different childhood environments effected these

skills in relationship to graphics courses.[8] Benninger and Newcombe did a meta analysis looking at a number of studies on experience and spatial visualization abilities.[9]

There are several tests available to test spatial visualization skills. The Purdue Spatial Visualization Test, PSVT is commonly used.[10] It consists of 30 problems, all in the form of figure 1. The student is to select the choice that illustrates the position of the middle solid if it were rotated as the top solid. Another tool is the Mental Rotation Test, MRT.[11] This test is a similar rotation test to the PSVT but with less solid objects, chain-like structures build with connected blocks. The Mental Cutting Test (MCT) was developed as part of the university entrance exam and asks students to identify the two-dimensional image on a plane that cuts through a solid object.[12] Another test is the Differential Aptitude Test: Space Relations (DAT:SR) that consists of 50 items.[13] The questions show a two-dimensional plan that, when folded, becomes a three-dimensional solid. The student is to select the correct solid from four choices.

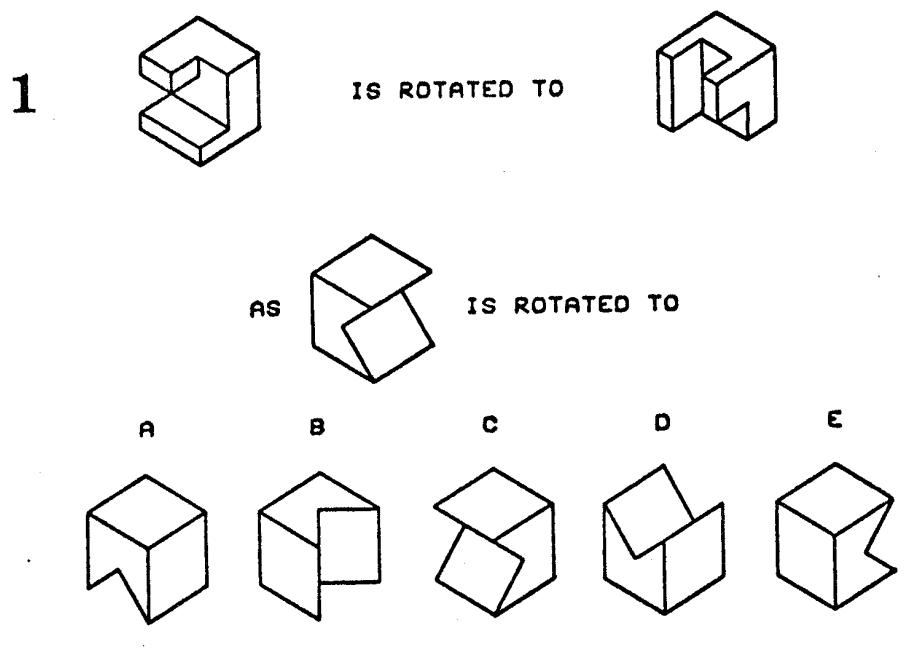

Figure 1, Sample of a PSVT problem.

II. Project Description

While the correlation between spatial visualization and engineering graphics seems intuitive, does the visualization skills transfer to other courses; for example, the first course in vector mechanics, statics? Many consider statics as one of the first really engineering courses students outside the math and science prerequisite; notwithstanding, that more and more engineering curricula are introducing design in the freshman year. Students are introduced to space trusses and other 3-D structures in this course as well as many 3-D drawings in the text to illustrate other problems. Just as plane geometry in high school is thought by some to improve reasoning skills,

some of the authors cited previously and others believe spatial reasoning is an aid to more general logic and problem solving, especially in engineering design courses.[141516]

At North Dakota State University, there is a course for freshmen who want to study engineering but are not sure which department or what kind of engineers they want to be. This class has an enrollment between 40 and 60 students. In 1996 the PSVT was given to a class of 42 students. The test was repeated in the Fall of 1999 and 2000. Not enough of the students in the last two courses have taken statics to allow for statistical analysis, so only the data from the 1999 class has been analyzed. The PSVT scores were compared with the grades in statics to determine if there was a correlation. Because only 19 students continued in engineering, the sample size does not allow for significant conclusions; however, as subsequent students take statics, more conclusive evidence will either confirm and disallow the tentative results of this first sample.

Figure 2 shows the scatter diagram where the PVST score is the independent variable and the grade in statics is the dependent variable. Table 1 gives the statistics of the sample. Thought the coefficient of the independent variable, PSVT, is slightly negative, the low "r" value renders it uninteresting as a predictive tool.

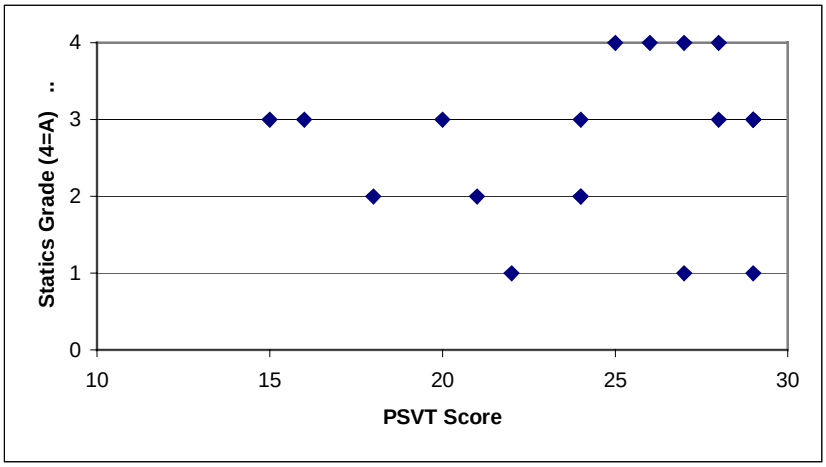

Figure 2, Scatter Diagram of the PSVT score and Statics Grade

Regression Statistics	
Multiple R	0.105722971
R Square	0.011177347
Adjusted R Square	-0.046988692
Standard Error	1.026212177
Observations	19

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	2.88813314	1.326692673	2.176942	0.043867
X Variable 1	-0.023589001	0.05381148	-0.43836	0.666642

Table 1, Results of the PSVT-Statics Regression

Interestingly, there was a slight positive correlation between the PSVT scores and the GPA of the whole class. The statistics of this are given in Table 2. However, there was no significant difference between the PSVT and GPA of the engineering students. Also, there was no significant difference in PSVT scores between the students who stayed in engineering and those who left for another major. Students who failed out of the university had a slightly lower PSVT average than those who persisted (only about two points).

Regression Statistics	
Multiple R	0.281868
R Square	0.07945
Adjusted R Square	0.056436
Standard Error	0.713765
Observations	42

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	1.373644683	0.708622653	1.938471	0.059645
X Variable 1	0.053979173	0.029051859	1.858028	0.070536

Table 2, Results of the PSVT-GPA Regression

III. Conclusions

From the literature, there appears to be a significant correlation between spatial visualization skills and success in engineering graphics courses. There also appears to be a significant improvement in both spatial visualization and grades in graphics courses when students are taught spatial visualization skills. Apparently female students, who normally have lower spatial visualization skills than males realize greater improvement and can reach parity with male students.[17] Hsi, *et. al.*, found that only one hour of extra instruction was necessary to correct the gender disparity. The course instituted by Sorby and Baartmans was a semester course. From these two studies, it would appear that significant improvement in spatial visualization skills may be effected by less that a semester course.

Thus far, the data collected at NDSU does not suggest a correlation between spatial visualization skills, as measured by the PSVT and success in statics. This is not too surprising because the 3-D skills in statics are significantly less than in an engineering graphics course. What would be of interest is to determine if spatial reasoning skills are correlated with other engineering design skills. Of even more interest are the studies that attempt to find aptitudes in other areas that effect success in engineering studies. This area needs to be studied more so early intervention may be taken to improve retention and success in engineering programs.

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