Improving Visualization Abilities in Minority Engineering and Technology Students: Preliminary Results

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ABSTRACT*- Students taking a two course series in introductory mechanical drawing and CAD at Virginia State University had significantly lower than average test scores on the Purdue Spatial Visualization Test: Visualization of Rotations (PSVT) when it was administered during the first week of class. One section of the first course, a primarily 2D focused course, received remediation in the form of a variety of in-class and homework assignments including sketching and CAD work and the students' posttest scores improved significantly. The semester following the initial implementation of the remediation course, all students enrolled in the 3D focused second course in the series, both those who received remediation in the first course and those who were enrolled in a different section, were given the PSVT as a pre and posttest. The scores of the students who had not received remediation were significantly lower at the beginning of the course than those who had received remediation, but there was some improvement in their posttest scores.*

I. INTRODUCTION

The Purdue Spatial Visualization Test: Visualization of Rotations (PSVT) was used to measure the visualization abilities of engineering and technology students at Virginia State University, a historically black university (HBCU). Previous research [1] had shown that these students had lower than average scores on the PSVT and remediation was implemented to attempt to improve the visualization abilities of these students.

Studies such as those conducted by Sorby at Michigan Technological University [2] have shown that women, who had similarly low pretest scores as did the minority population in this study, with adequate remediation in a spatial skills course, could improve their test scores to the level of non-minority males. In Sorby's study, over the long term, subjects who initially scored low on the PSVT and then enrolled a spatial skills course had significantly higher GPAs in subsequent engineering graphics courses than did a comparison group. The rate of retention in engineering was also significantly higher for those subjects who took a spatial skills course for remediation than for those who did not. It was hoped that remediation used to improve the visualization abilities of the minority subjects in this study would have a similar positive effect on overall academic success.

II. STUDENT DEMOGRAPHICS

Virginia State University is a historically black university (HBCU) with a student population that self-identifies as 98% black. The general characteristics of the subjects in this study include an average high school GPA of 2.62 and mean combined SAT score of 802 [3]. From 2002-2005 the mean nationwide combined score for all subjects taking the SAT was 1025 and the mean score for blacks nationwide was 858 [4]. The average age of the subjects in the study was 19 and they were typically first and second semester freshmen with some first semester sophomores and eighty-seven percent of the subjects were male.

Entry requirements for students wishing to major in the Department of Engineering, Engineering Technology and Industrial Education and Technology at VSU include: a cumulative 2.2 GPA on a 4.0 scale; three units of mathematics including algebra I, and either geometry or algebra II; and two or three units of science, one of which must be a laboratory science [5]. These requirements were effective for entry in Fall 2005, previous admissions requirements were the same except for a minimum high school GPA of 2.0.

Most students in this study were concurrently enrolled, or had been enrolled the previous semester, in an introduction to engineering and technology course where they are administered a freshman diagnostic math foundations test. This test covers; fractions, decimals, ratios/proportions and percents, integers, powers and exponents, coordinate geometry, measurement, geometry in plane, geometry in space, algebra and expressions, algebra and equations, radicals, word problems, and graph problems. The mean pretest score for freshmen was 59.7 percent and posttest mean was 76.6 percent [6].

III. COURSE DESCRIPTIONS

The subjects in this study were enrolled in one of two courses, DRFT 161 or DRFT 261. DRFT 161 focuses on 2D mechanical drawing / drafting and incorporates both hand sketching and 2D CAD. Topics covered throughout the course include orthographic projection, section views, auxiliary views, and basic dimensioning. There is no prerequisite to DRFT 161, and it serves as the prerequisite to DRFT 261, a course which focuses on 3D modeling, including CSG and parametric modeling. Topics covered in DRFT 261 include Boolean operations, extrusions and revolutions, extraction of multiview drawings from 3D models, dimensioning, 3D assembly, and animation of assemblies. Most engineering and technology students at VSU are required to take DRFT 161, unless they have previous experience in mechanical drawing / drafting and receive consent from both their advisor and the DRFT 261 instructor to skip DRFT 161 as a prerequisite.

IV. PRETEST SCORES

The PSVT was administered to all students attending class during the first week of the semester for DRFT 161 courses in the Fall semesters of 2003, 2004, and 2005. The mean pretest scores for each semester were; 13.6 in 2003, 15.7 in 2004, and 15.8 in 2005 with a grand mean of 14.6 for 55 subjects.

Students in DRFT 261 were also administered the PSVT during the first week of the semester during the Fall and Spring semesters of 2003 through 2005. The mean pretest scores for each semester were; 13.5 in Fall 2003, 17.8 in Spring 2004, 15.8 in Fall 2004, 17.2 in Spring 2005, and 13.1 in Fall 2005, with a grand mean of 16.4 for 46 subjects.

The scores for the students in DRFT 261 were also analyzed according to whether the students had taken as a prerequisite the section of DRFT 161 which contained remediation exercises intended specifically to enhance students' visualization abilities. The pretest scores of those who had received remediation in DRFT 161 had a mean of 22.2 while the mean score of those students who had either not taken the prerequisite at all, or not taken the course with remediation, was 15.0.

V. REMEDIATION ACTIVITIES

Because of an inadequate increase in scores on the PSVT posttest compared to the pretest for subjects taking DRFT 161 in the Fall semester of 2003, beginning in the Fall semester of 2004, additional remediation exercises to supplement ordinary course instruction were introduced into the course. Students were given five additional assignments which focused

solely on sketching and visualization, both in class and for homework, and were required to sketch the answer to most CAD assignments and have the sketches checked by their instructor before beginning work on the computer.

The sketching homework and classwork exercises included missing view and missing line problems, multiview sketches from isometric drawings, and section and auxiliary view exercises. Each assignment had at least six and up to 20 sketches to complete. There was also a sketching and/or visualization component included in each test throughout the semester and on the final comprehensive exam. In the initial offering of the course in Fall 2003, the percent value placed on sketching and visualization on written tests was approximately 25 percent of the test grade and the subsequent remediation focused courses had an average of 40 percent of the test points in sketching.

VI. POSTTEST SCORES

The PSVT was administered as a posttest to all students remaining in both DRFT 161 and 261 during the 14th or 15th week of the semester. The mean posttest score for DRFT 161 for the Fall semester of 2003 was 17.6. This section of the course did not receive additional remediation exercises. The mean posttest score for Fall 2004, the first course to receive remediation, was 23.3. The grand mean posttest score for all students in DRFT 161 is 19.0. Posttest scores for Fall 2005 are not yet available.

Posttest scores for students enrolled in DRFT 261 were; 17.7 in Fall 2003, 20.0 in Spring 2004, 18.1 in Fall 2004, and 20.5 in Spring 2005. The mean posttest score in the Spring 2005 semester for those students in 261 who had received remediation the previous semester in DRFT 161 was 23.6 while the mean of those who had not received remediation was 17.8. The grand mean posttest score for all subjects who have taken DRFT 261 is 19.8.

VII. DISCUSSION

Students in the section of DRFT 161 that received remediation had an increase in their PSVT scores from a pretest mean of 15.7 to a posttest mean of 23.3, which showed a higher increase than the course which did not receive remediation and only had an increase in the mean from 13.6 to 17.6 (Figure 1). However, with data from only one remediation section of the course thus far, it is not possible to make any statistical correlations between the use of the 2D sketching and visualization exercises and the increase in scores. The course, with remediation, is being offered again this Fall semester and while pretest data has been collected, the posttest has yet to be administered.

	Pretest Mean	Posttest Mean
All DRFT 161 Scores	14.6	19.0
DRFT 161 N*	13.6	17.6
DRFT 161 R**	15.7	23.3

* Subjects who did not receive remediation
** Subjects enrolled in course with remediation

Figure 1. DRFT 161 Pre and Posttest PSVT Scores

Overall, these preliminary results seem to indicate that the materials and information covered in the 2D course, DRFT 161 increases visualization scores more than the 3D course, DRFT 261, does. The mean pretest score for all students in 161 was 14.6 with a posttest mean of 19.0 while the mean scores for all students in 261 rose from a pretest mean of 16.4 to a posttest mean of 19.8.

Students in the remediation section of 161, who took 261 the next semester, had a 261 pretest score 22.2 and a posttest score of 22.3 indicating that the content in the 3D focused course did not significantly improve their

visualization abilities above the level they had already achieved in 161, the 2D course. However, in the same section of 261, students who had not previously received remediation had a pretest mean of 14.3, which was similar to the pretest scores of all 161 students, and a posttest mean of 17.8 which showed some improvement but did not bring them up to the mean of students who had received remediation in 161. The mean pretest score for all students who had not taken a prerequisite to 261 was 15.0 and the posttest mean was 18.5 (Figure 2).

	Pretest Mean	Posttest Mean
All DRFT 261 Scores	16.4	19.8
DRFT 261 N*	15.0	18.5
DRFT 261 R**	22.2	22.3

* Subjects without remediation or without prerequisite
** Subjects receiving remediation in DRFT 161

Figure 2. DRFT 261 pre and posttest scores

Visualization ability has been linked with success in math and science, and as was previously noted, the students in this study had lower than desired skills in basic math, including algebra and geometry. However, their diagnostic math test scores improved over the course of the semester and whether that can be attributed to the college algebra and trigonometry course, the intro to engineering and technology course that administered the diagnostic test, the mechanical drawing course DRFT 161, or a combination of all three has not been determined.

More data must be collected over the long term to determine the success of the remediation in DRFT 161 and its affect not only on that course, but on the subsequent course, DRFT 261, and on the students' overall success in their major. Since VSU is a small university, and class sizes in DRFT 161 and 261 are typically 10-20 with only one section every semester, or even every other semester depending on need and availability of faculty, it will take some time to gather enough data to have statistical significance.

VIII. REFERENCES

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