Implementing *ENGAGE* Strategies to Improve Retention: Focus on Spatial Skills
Engineering Schools Discuss Successes and Challenges

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Note: This Virginia Tech contribution was not ready in time to be included in the proceedings paper with the other contributing schools so it is presented as an addendum.

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Introduction
The ENGAGE team at Virginia Tech initiated the Purdue Spatial Visualization Test: Visualization of Rotations (PSVT:R) during onsite summer orientation for incoming first-year engineering students. Paper versions of the tests were given in groups of 50 to 100 students over two weeks in July 2010. A total of 1085 students took the test to assess the spatial visualization skills of incoming first-year engineering students. Those scoring below 18/30 on the spatial visualization skills test were enrolled in the one credit, A/F, elective, Spatial Visualization course offered in fall semester 2010 by the Department of Engineering Education using Sorby's text* *Introduction to 3D Spatial Visualization: An Active Approach*. As this course had been taught in the past for pilot research studies, the course had been approved by all appropriate curriculum committees and ready to be taught last fall by one of our Ph.D. students who was an experienced engineering graphics/CAD instructor. The team's goal this summer is to require the online version of the PSVT:R test for all incoming first-year students, identifying all first-year engineering students scoring below 18/30, and enrolling them in the course prior to their coming to summer orientation.

Approach
To identify high-risk students, incoming students were screened using the Purdue Spatial Visualization Test: Visualization of Rotations (PSVT:R) during onsite summer orientation. The test was announced during general engineering orientation sessions given by the interim department head. She described the opportunity and the importance of strong spatial visualization skills for success in both engineering courses and professional engineering practice. Students had time in their orientation schedule to take the test and students were strongly encouraged to do so. The recruiting was very effective. So much so, when an occasional student missed the start time, they needed to be assured that missing it would not affect their registration process. A below 60% threshold was established as a cut-off score based on prior research by Sheryl Sorby. One thousand eighty five (1085) students took the test. Some students missed the screening because they did not come to orientation. Also, some students attending the first day of orientation missed the opportunity to be screened due to an attempt to implement the online test which proved to be problematic in setup and implementation. Students who scored below the threshold were automatically enrolled in the course and could then drop if they chose to do so. One hundred and five

(105) students were enrolled and due to dropping and schedule conflicts, seventy-one (71) students started the course.

Course Structure

The spatial visualization course consisted of consisted of a semester long weekly 75 minute class session consisting of modules in Sorby's text* *Introduction to 3D Spatial Visualization: An Active Approach* (number represents the module number in this text) plus additional modules on orthographic projection with inclined and curved surfaces. The sequence of the modules taught was 9-Combining Solids; 8-Surfaces and Solids of Revolution; 1-Isometric Sketching; 2-Orthographic Projection; 3-Flat Patterns; 4-Rotation about single axis; 5-Rotation about multiple axes; 6-Reflections and Symmetry; and 7-Cutting Planes and Cross Sections. All students met weekly in class in a single section of 71 students. The spatial visualization class was organized by an Engineering Education faculty member and was taught by and experienced Engineering Education Ph.D. student. The format of the course was interactive with some contextual examples to emphasize the importance of spatial visualization skills and then moving onto students working in the workbook with instructor available for assistance. Students were encouraged to work on more examples at home, but most could be completed during the class.

Test Results and Outcomes

Pre-test PSVT:R scores of the 1085 students taking the test averaged 23.8/30. The pre-test scores of the students falling below the 60% threshold and enrolled in the course was 16.3/30. Of the105 students who scored below 60%, 60 were male, 45 were female. Of the 71 students actually enrolled in the class, 33 were male and 38 were female. After participating in the course, the students again took the PSVT:R post-test had an average score of 21.4. Five (5) males and nine (9) females fell below the 60% threshold after completing the course. The screening of the students was effective in identifying students who would benefit from the course (roughly 10%), but could improve to screen even more students. The course was effective in training the students to improve their spatial visualization skills, but still 20% of those taking the course did not have their scores improve enough to exceed the threshold.

On-Going Plans and Challenges

Based on the smooth screening process and the response of the students to taking the test, the team plans this year to expand screening to reach more students and to use the online PSVT:R. Students will be informed and encouraged via e-mail to register and take the online PSVT:R as part of ongoing communications between Engineering Education academic advisors and incoming first-year engineering students. Students will be given a two week window to take the test, after which they will be warned that a hold may be put on their enrollment. Once the test is taken and the scores are noted, students will be enrolled in the Spatial Visualization course prior to their arrival at orientation so the course will show with other courses on their fall academic schedule. The course will then be taught in the fall in one or two sections depending on enrollment.

*Sorby S. A. and Wysocki, A. F. (2003). *Introduction to 3-D Spatial Visualization: An Active Approach.* Thomson Delmar Learning, Clifton Park, New York.

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