Instructional Strategies for Supporting Student Learning of Graphical Design Skills

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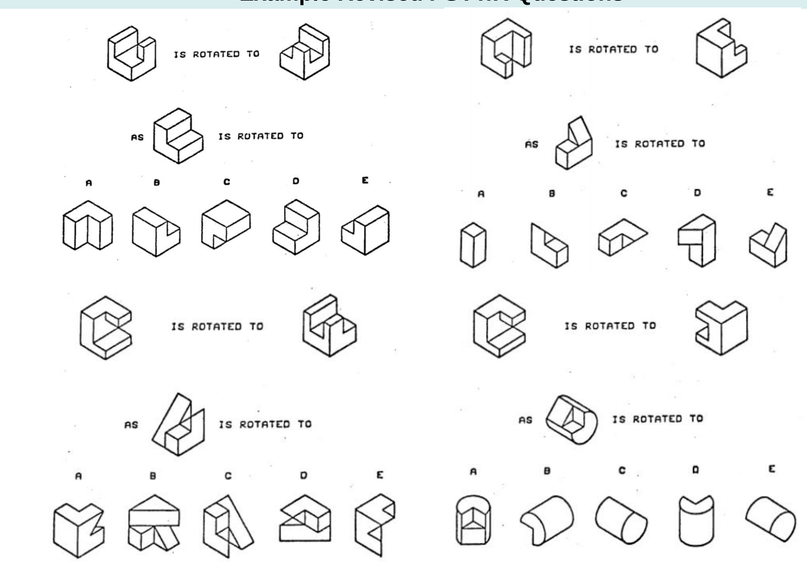
Introduction

- Instructional strategies were implemented in an introductory biological systems engineering course (EBS 1) that were focused on improving student learning experiences of graphical and computer-aided design (CAD) fundamentals.
- Curriculum was developed that was student-centered, engaging, and relevant to the course topics of food, agricultural and biotechnical engineering.
- Course curriculum offered opportunities for all students, regardless of prior CAD experiences, to develop the fundamental technical skills and problem-solving strategies necessary to create their own three-dimensional digital solid models.
- The Revised Purdue Spatial Visualization Test: Visualization of Rotations (PVST:R) was utilized to assess spatial visualization skills before and after the course, where students learned CAD skills during a ten week quarter.
- Research on spatial visualization highlights the importance of these skills to success in technology and engineering fields (Norman, 1994).
- Targeted instructional strategies can further develop student 3-D spatial skills (Sorby, 2009), thus contributing to their academic success.
- This work aimed to understand the impact of the instructional strategies on student learning of CAD skills in an introductory engineering course, and to assess connections between student spatial visualization skills and CAD competency.

The Revised Purdue Spatial Visualization Test (Revised PSVT:R): Visualization of Rotations

- The Revised PSVT:R test was used as a pre- and post-course assessment of student spatial visualization skills (Table 1).
- Questions of increasing difficulty were used to gauge spatial visualization and rotational skills necessary for 3D CAD model development.

Example Revised PSVT:R Questions



Answers, clockwise from top left: D, B, C, E

Student Pre-Class Reflection on Prior CAD Experience

- 58% of students had no prior experience with CAD
- 29% had some experience (e.g., used in camp or for a project)
- 13% had a fair amount of prior experience (e.g., took a class)

3D Graphical Visualization Topics

Instructional Strategies Utilized

- Implemented Onshape Education Enterprise, a professional and freely available CAD platform with features beneficial to student-centered learning in a course taught with remote instruction in Fall 2020.
- Developed a series of interactive activities for lab sessions, that began with 2D CAD sketching skills and progressed to more advanced 3D modeling techniques (Chester, 2007).
- The learning trajectory was developed for students who had no prior experience using CAD software or with 3D graphical visualization.
- In-class examples and design assignments were tailored to be tangible objects or items related to the biological systems engineering major to increase student engagement with the material.
- Step-by-step visuals and videos for labs activities were developed and provided for student reference.
- Individual, open-ended project assignments encouraged student skill development, creative expression, and peer learning opportunities.

Relationship between PVST:R Spatial Visualization Skills and Open-Ended Design Project

- After 3 weeks of instruction, students were assigned an open-ended design project to develop a decorative charm.
- Student design projects were assessed for difficulty by two independent reviewers using a scoring rubric (Table 2).

Table 1. Student PVST:R scores from before and after the course, with individual student change from pre- to post-test (n = 28 students who completed both tests).

PVST:R Score	Pre-Course	Post-Course	Δ Pre- to Post-Course
Average	19.9	22.4	2.5
Median	21	24	2
Standard Deviation	5.8	4.9	4.2

Table 2. Scoring rubric used to determine a difficulty score on student open-ended design projects.

Project Difficulty Score	Criteria
1	Simple sketch, extruded
2	Slightly more complex sketch, extruded (could be extruded to varying depth)
3	A few different shapes of varying depth extruded
4	Multiple different shapes of varying depth/dimension extruded
5	Complex, multiple depths and shapes

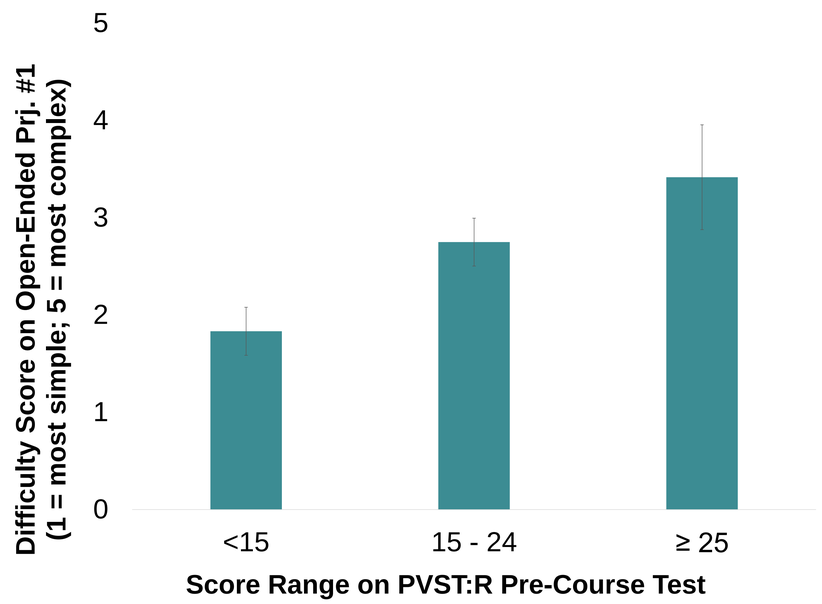


Figure 1. Relationship between student pre-test score on the PVST:R spatial visualization test and the scored difficulty on their first open-ended CAD design project. Values represent averages for each score range (n = 6 – 16 per group) and error bars are the standard error of the mean.

Conclusions

- **Open-ended design projects** allowed students to **remain engaged** while **developing designs within their skill level**.
- **Student PVST:R pre-test scores correlated with complexity** on their first open-ended design project, particularly for students with the highest (≥ 25) and lowest (< 15) PVST:R pre-test scores.
- Student **PVST:R scores increased** by an average of 2.5 points after completing the CAD course. Future studies are required to determine if post-test scores are correlated with student CAD design projects completed near the end of the course.

References

Chester, I. (2007). Teaching for CAD expertise. *Intl J of Tech & Design Ed*, 17(1): 23-35.
Norman, K.L. 1994. Spatial visualization – A gateway to computer-based technology. *J. of Special Educational Tech.*, XII(3): 195–206.
Sorby, S. A. (2009). Developing 3-D spatial visualization skills. *Eng. Design Graphics J*, 63(2): 21 – 23.

Acknowledgements

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