Exploring correlations between student motivation and scores on the Purdue Spatial Visualization Test: Rotations

Pujan Thaker[1] & Jennifer Bailey[2]

1. Embry-Riddle Aeronautical University, 2. Rochester Institute of Technology

BACKGROUND

Spatial Visualization (SV) is an important skill in which students can mentally rotate two-dimensional and three-dimensional objects. This skill is very important in STEM fields, more specifically in engineering. Spatial Visualization training is linked to higher retention rates in engineering. Having well-developed SV skills not only increases student success in STEM courses, but also in their future careers. For example, astronomers use SV skills to visualize the structure of the solar system and the motions of the planets, while radiologists use SV skills to interpret a medical x-ray.

Figure 1: *An astronomer viewing stars through a telescope*

Figure 2: *A radiologist looking at X-Ray scans*

Most departments at universities incorporate SV training into the freshman engineering curriculum through introductory engineering courses. At RIT, freshman biomedical engineering students are required to take BIME 181 Introduction to Biomedical Engineering. The course serves as an intro to the field of biomedical engineering and engineering methodology and how it relates to biomedical issues. The course also introduces students to important skills such as teamwork, research, and communication. In the fall of 2017, the course was restructured to introduce SV and design thinking skills to students. Prior to 2017, SV was not included in the curriculum of BIME181.

OBJECTIVES

1. How the curriculum of the course restructuring impacted student's SV skills
2. Whether or not the frequency of workshops impacted student SV skills
3. How did student motivations impact overall cohort scores

METHODS

- Starting in 2015, the PSVT:R (Purdue Spatial Visualization Test: Rotations) was administered to BIME181 students to assess their SV skills
- Students had 30 minutes to complete 25 questions
- Sample question from PSVT:R

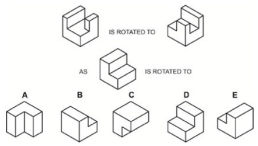

Figure 3*: A sample question from the PSVT:R*

METHODS

- Once the course was restructured in 2017, post-tests were administered once the course ended to determine any improvement in SV skills due to the restructuring
- Cohorts from 2017, 2018, 2019, and 2020 were exposed to SV skills. through workshops and in-class activities
- All test scores were recorded from 2015-2020
- Scores in the analysis are representative of students who completed both the pre- and post-test as students who did not complete either a pre or post-test were omitted from this dataset
- Data was statically analyzed (averages, standard deviations, ANOVA, and t-tests) to determine if there was significance
- Any improvements in overall in cohort performance was determined through learning gains
- Learning gain is a way to measure student's learning between the beginning and end of a course
- The formula to calculate the learning gain is:

$$\frac{post\ score\ - prescore}{30 - prescore}$$

where 30 was the highest score possible on the PSVT:R

- Student motivations for completing the PSVT:R were also considered based on cohort

RESULTS

Table 1: Results of statistical analysis from the 6 cohorts

Cohort	# of students	Average Pre-Score	Standard Deviation of Pre-Score	Average Post-Score	Standard Deviation of Pre-Score	Learning Gains	ANOVA pre-score p-value	ANOVA post-score p-value
2015	73	21.9	5.01				0.794	
2016	51	21.5	4.72					
2017	44	21.3	3.99	25.1	3.02	0.45		0.0064
2018	59	21.4	4.90	21.8	5.25	0.09		
2019	53	22.5	4.43	23.3	4.43	0.04		
2020	73	21.4	5.17	22.9	5.1	0.17		

- Based on the average pre- scores of the cohorts, it can be determined that the incoming freshman start on similar levels of each other
- The post-scores were only collected from 2017-2020

RESULTS

Table 2: Instruction type and motivation based on cohort

Year	Rotations Practice	Post-Quiz Motivation	SV Instruction Focus
2017	Yes	Score impacted final grade	Peer activity
2018	No	Participation grade	Worksheet with peer activity
2019	2/3 of the section	Participation grade	Worksheet with peer activity
2020	Voluntary during lecture time	Participation grade	Worksheet with peer activity

- Focus is only on 2017 and 2019 cohorts
- PSVT:R impacted final course grade in 2017
- In 2019, approx. 2/3 of the cohort had rotation practice

Table 3: Total amount of time spend teaching SV topics per cohort

Cohort	# of students	Total time spent in class (hr.)	Number of classes at least in part used for SV topics	Average Pre-Score	Average Post-Score	Learning Gains
2017	44	2.5	2	21.3	25.1	0.45
2019	53					
1	35	2.5	2	22.3	23.02	0.09
2	18	2	1	22.89	23.89	0.14

- Fall 2017 cohort has higher learning gains than 2019
- In 2019, students that had less exposure to SV topics had higher learning gains

CONCLUSION

The 2017 cohort pre-score was 21.3 and the post-score was 25.1. The 2019 cohort was split into two groups. One group had two class sessions covering Spatial Visualization (2) topics. Their pre-score was 22.3 and the post-score was 23.02. The other group was only exposed to SV topics once. Their average pre-score was 22.89 and their average post-score was 23.89. The group exposed to SV topics twice is comparable to the fall 2017 cohort, as they both spent the same amount of time in class covering SV topics. However, the 2017 cohort had a higher learning gains than the 2019 cohort. In 2017, the PSVT:R score impacted the final course average while in 2019, the PSVT:R counted as a participation grade. It can be concluded that due to the of impact PSVT:R on the final grade, the 2017 cohort had more reason to perform well on the test. However, the 2019 cohorts may not have had much motivation to perform as well as the PSVT:R was a participation grade. Student motivations to complete the PSVT:R may indicate why the 2019 cohort had lower learning gains.

REFERENCES

1. [1] Sorby, S., Casey, B., Veurink, N., & Dulaney, A. (2013). The role of spatial training in improving spatial and calculus performance in engineering students. Learning and Individual Differences, 26, 20–29.
2. [2] Guay, R.B. Purdue Spatial Visualization Test – Visualization of rotations. West Lafayette, Indiana: Purdue Research Foundation, 1977.
3. [3] Bailey J., Dobie D., Wick D. "Work in Progress: Designing an introduction to biomedical engineering course around a design challenge," ASEE National Conference and Exposition, Salt Lake City, Utah, 2018.