The Effects of Increasing Quantitative Data in the Design Process in an AP Physics Class

Pamela Joslyn, Central School, Muscatine, Iowa

MONTANA STATE UNIVERSITY
Master of Science in Science Education

Background

This research was conducted at Central Middle School, a public middle school located in Muscatine, Iowa. Engineering provides a framework in which students can test their own developing scientific knowledge and apply it to practical problems. When students engage in science investigations and engineering design, they are able to engage genuinely with phenomena as they ask questions, collect and analyze data, generate and utilize evidence and develop models to support explanations and solutions. Deeper engagement leads to greater conceptual understandings of science content. Constructing understanding through the design process in science investigations creates meaningful and memorable experiences, stimulating students' curiosity (National Academies of Sciences, Engineering, and Medicine, 2018).

Research Questions	Data Collection Instruments 1	2	3
Will an increase in quantitative data in the design process increase student understanding?	Pre-, Mid-and Post- unit, assessment, multiple choice questions	Lab reports with rubric	Pre-, Mid-and Post- unit short answer questions
Will qualitative artifacts in the design process improve student understanding?	Surveys	Interview	Instructional coach observations
Will the design process affect student perception of content understanding?	Interview and questions	Attitude survey	Student self-reflection

Methodology

- The study was conducted on 44 eighth grade students.
- The treatment and nontreatment phase extended over a six-week period.
- Both the non-treatment and treatment students were instructed with a 5 E learning cycle approach.
- Using lasers, photoreceptors, a PVC frame, and duct tape, all students built a security system to protect the class "troll."
- The treatment group were required to measure the angle of incidence and reflection. (Fig. 1) The nontreatment group was not required to take any measurements.

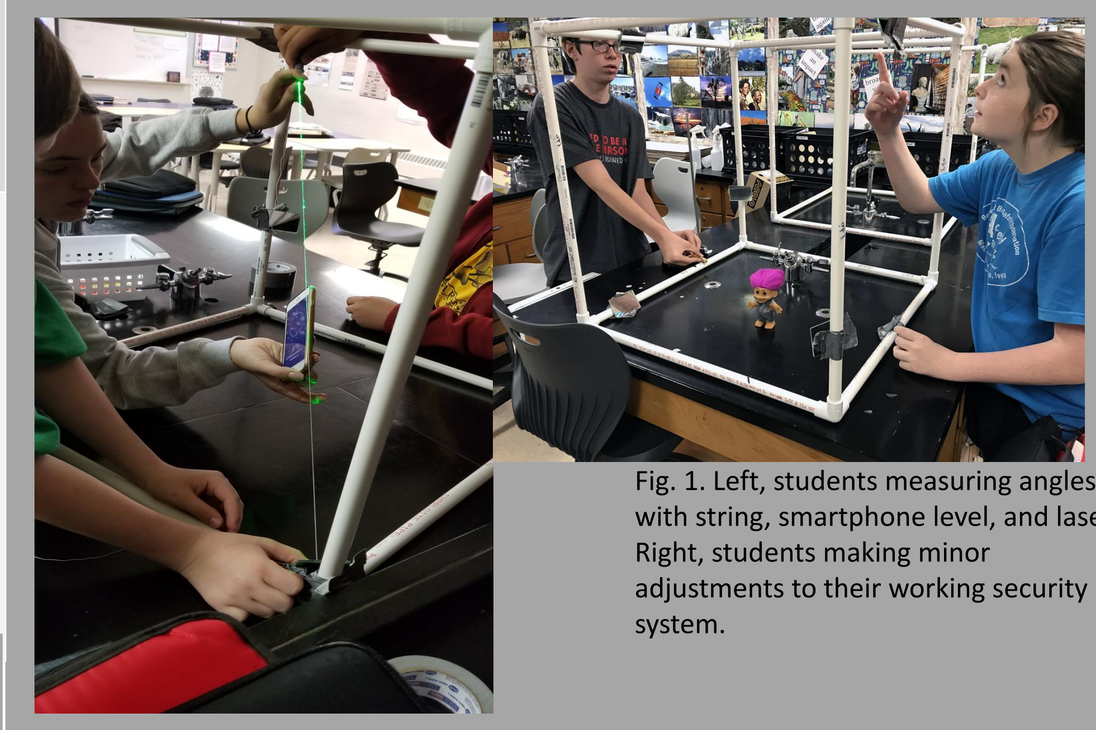

Fig. 1. Left, students measuring angles with string, smartphone level, and laser. Right, students making minor adjustments to their working security system.

Data and Analysis

- Students in treatment group showed a normalized gain of 0.35 while the nontreatment group showed a normalized gain of 0.08 on the multiple choice test. The short answer questions indicated a normalized gain of 0.17 for the nontreatment group with a 0.25 normalized gain for the treatment group.
- Both the treatment and nontreatment showed an increase in awareness that data improves the design (Fig. 2)

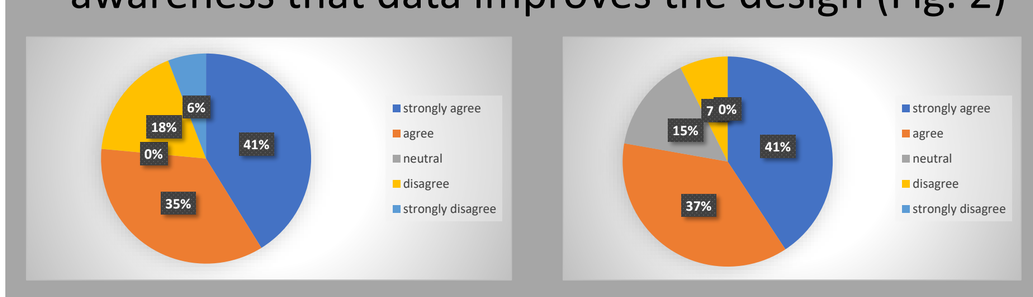

Fig. 2 Left treatment group, right nontreatment group

Fig. 3 Left multiple choice questions, right short answer questions

Conclusion

This study supports that adding quantitative design improves content understanding with marginal gains. The results from the unit reflections indicated that the students were more confident during the treatment units and could apply their knowledge more readily when the students participated in the design process. Students felt strongly that engineering made learning more relevant in the science classroom. The reflections also indicated students frustration with failure in the design process. Students gained a greater appreciation of engineering and appreciated real world applications. My favorite student quote: "I love engineering, but the laser project made me love it more."

References

National Academies of Sciences, Engineering, and Medicine. 2018. *Science and Engineering for Grades 6-12: Investigation and Design at the Center.* Washington, DC: The National Academies Press.