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The Impact of Project-based Learning on Engagement as a Function of Student Demographics

Ms. Alyssa Bellingham, Drexel University

Alyssa Bellingham is currently an electrical engineering Ph.D candidate at Drexel University. She recieved her B.S/M.S degrees in electrical engineering from Drexel University in 2012 and has a degree in materials engineering from Politecnico di Milano. As a National Science Foundation Stem GK-12 Program fellow, she has been teaching a robotics course at the Science Leadership Academy in Philadelphia.

Mr. John Kamal, Science Leadership Academy

John teaches young people engineering and science at Science Leadership Academy in Philadelphia. John came to SLA through the Philadelphia Teaching Residency Program as a Noyce Scholar.

Prior to teaching, John spent a few decades as an entrepreneur, co-founding WAM Systems, a global provider of supply chain planning and optimization solutions to large manufacturers. Before WAM, he designed spacecraft at GE for many years. John holds engineering degrees from Penn State and Villanova.

When not teaching science and engineering, John can be found playing jazz clarinet, practicing yoga, or inventing oddities in his workshop.

Jessica S. Ward, Drexel University

Jessica Ward serves as the Director of Operations for the DragonsTeach program. She previously worked in the College of Engineering at Drexel University for more than 9 years with a focus on recruitment, grant facilitation and STEM program management. During her tenure in the College of Engineering, Jessica successfully coordinated with multiple faculty members in the submission of approximately 600 grant proposals, including co-writing, editing and serving as the Program Manager for 5 awarded STEM education grants totaling more than $12M. She has collaborated with University offices and College faculty and professional staff in the facilitation of recruitment strategies to increase the quality and quantity of undergraduate and graduate enrollment, including supervising the planning and implementation of Open House and other recruitment events. Jessica now manages the day-to-day operations of the DragonsTeach program, including supporting the development of programs of study, student recruitment, fundraising and grant-writing, hiring and supervising staff and student workers as well as coordinating program evaluation.

Dr. Adam K. Fontecchio, Drexel University

Dr. Adam Fontecchio is an Professor of Electrical and Computer Engineering, Vice-Dean of the Graduate College, and Director of the Center for the Advancement of STEM Teaching and Learning Excellence (CASTLE). He is the recipient of a NASA New Investigator Award, the Drexel Graduate Student Association Outstanding Mentor Award, the Drexel University ECE Outstanding Research Achievement Award and the International Liquid Crystal Society Multimedia Prize. In 2003, he received a NASA/ASEE Summer Faculty Fellowship to research NEMS/MEMS adaptive optics in the Microdevices Laboratory at the Jet Propulsion Laboratory. Dr. Fontecchio received his Ph.D. in Physics from Brown University in 2002. He has authored more than 90 peer-reviewed publications.

The impact of project based learning on engagement as a function of student demographics

Abstract

This work in progress seeks to determine the role of demographics in student inclination to choose science, technology, engineering, and mathematics (STEM) electives in high school. A Ph.D. student fellow from Drexel University and teacher from the Science Leadership Academy (SLA) in Philadelphia will teach robotics and engineering principles through open-ended projects that address several of the NEA grand challenges. These projects are structured using constructivist pedagogy that ties into five core values: inquiry, research, collaboration, presentation, and reflection. We will introduce this study into an ethnically diverse robotics class comprised of sophomore, junior, and senior students. The predisposition of students to study topics relating to robotics will be assessed at the start of the study and then after each project has been completed. Initially, predisposition will be determined by which students selected this class as their first choice elective option and which were placed into the class based on scheduling. As the year continues, pre- and post-project surveys will be used to evaluate student interest and attitude towards robotics and engineering. This information will be broken down by demographics including, gender, age, and ethnicity to see if specific projects increase interest among certain groups. Although the sample size will be small, the goal is to establish a methodology and a preliminary outcome set that could be used in further research with larger populations.

Introduction

There is an ongoing struggle in the US to increase enrollment and retention in science, technology, engineering, and mathematics (STEM) fields to meet the demands of an expanding STEM workforce.[1] A large part of this struggle is that a large percentage of the population, including women, African Americans, Hispanics and Native Americans, are underrepresented in STEM fields.[2,3] Over the past few decades, there has been a steady increase in the representation of women and minorities in STEM fields post-college, but the demographics of these fields has remained largely unchanged and unbalanced.[4,5] This is due in large part to limited supply of female and minority graduates from STEM fields of study, which arises from the differences in preparation and educational experiences of these students.[6] Many interested in reducing this disparity have recommended focusing on increased teaching resources aimed towards engaging and interesting students in STEM fields throughout their primary and secondary school careers.[7–9] There has been a great push by many organizations, companies and individuals to do just that.

One example is the NSF GK-12 program which pairs graduate fellows in STEM programs with primary and secondary education teachers to develop and implement hands-on, inquiry based projects relating to STEM fields in the classroom. This program and others like it have led to the development of a vast supply of resources for teachers interested in increasing engagement and interest in STEM among their students. But with all these teaching resources available, student engagement in STEM classroom activities and lessons is still a concern. Student engagement is affected by a number of factors including interest in the topic, teaching style, and learning style just to name a few. This work in progress seeks to set up a framework to determine the role that demographics plays in student engagement and interest in STEM projects. Do certain STEM activities appeal more to one demographic group than another, and how might the instructor use

this to promote engagement in a diverse classroom? Also, does increased engagement in classroom STEM activities translate to increased interest in pursuing a STEM degree?

The methods of studying the role of demographics on engagement presented in this paper will provide a basis for answering these questions so STEM education can be further improved. By understanding the role of demographics on engagement, STEM activities can be tailored to engage a larger number of students, many of which may be underrepresented in STEM fields.

Research Approach

This study is being conducted at the Science Leadership Academy(SLA) in an elective robotics classroom with 28 total students, 18 of which are male and 10 who are female. A series of hands on activities and projects falling under one of four topics relating to robotics were developed by a Ph.D. research fellow from Drexel University and engineering/robotics teacher from SLA. The topics covered include:

Simple Robots

Using NXT Lego robot kits and software, students designed and built a robot that accomplished a series of challenges. Students then designed their own challenges to present to their peers and extend their understanding of robots.

Securing Cyberspace

Focusing on one the NAE grand challenges, this unit introduced hacking, programming and the necessity of cybersecurity. Students participated in an interactive game where they were charged with the task of keeping a hypothetical company safe from cyber attacks by completing hacking and programming tasks and then choosing the best defenses for protecting virtual data.

Electrical circuits

Electric circuits are the foundation for robotic movement. The basics of electrical circuits were taught through simple circuits that the students built and tested on bread boards.

Arduinos

Arduino is an open source electronics platform consisting of simple software and hardware that is easy to use and adaptable to many different projects and scenarios. Students are in the process of learning how to use Arduino boards and software through the context of a self-designed project where the students are developing and presenting a prototype of their own design involving the Arduino.

The students were given surveys at the beginning and end of each unit covering one of the listed topics to gauge interest and engagement in each topic. Initial interest in the course was gauged by how highly students in the class ranked robotics as an elective choice on a schoolwide survey where students rank elective choices offered by the school on a scale from 0 to 5, with 0 indicating no interest in the elective whatsoever to 5 being the student's top choice elective. This initial survey information was supplied anonymously by the school and did not include ethnicity.

The subsequent surveys were developed by the authors and included a section where respondents classified ethnicity, gender, and grade level. The surveys were composed of multiple choice questions less than five minutes in length to encourage student participation and make it easier to quantify the data. In the final survey, students were asked to rate this elective, based on their experience in the class. The same 0-5 scale used in the school wide survey was used in the final survey, meaning that students were ranking robotics against all other electives offered at the school.

Of the students polled, 41% are white/Caucasian, 34% are African American, 13% are Hispanic, 6% are Asian/Pacific Islander, 3% are Native American, and 3% do not identify with any of the listed ethnicities based on self-reported data. Students were allowed to select more than one ethnicity on the survey and several identified with more than one ethnic group. Students are in their sophomore (54%), junior (29%), and senior (18%) years of high school. Only 18% of students have a parent or guardian who work in a STEM field.

Results and Discussion

According to the elective survey results for the students enrolled in robotics, the average rating for the elective was a 1.75 out of 5, which indicates an initial lack of interest from the majority of the students. In fact, 30% of the total respondents ranked this elective a 0, which indicates that they had no interest in taking robotics as an elective. Prior to the start of class, only 39% of students had any experience in robotics, which may explain this low level of interest. More detailed responses to the elective rating survey broken down by gender are shown in Figure 1. On average, females ranked this elective much lower than males and none of the female students rated this as a top choice elective.

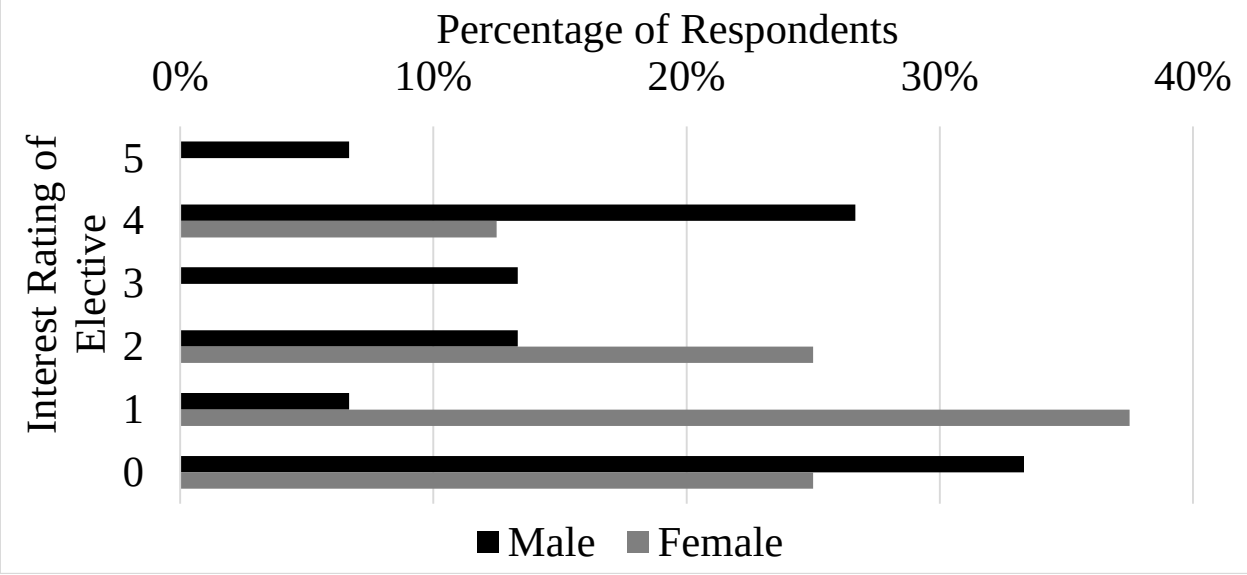

Figure 1 Initial desirability ranking of robotics elective among students

Although initial interest in the class was low, the four interactive units have had an overall positive effect on student interest in robotics. The results of final elective ranking survey broken down by gender are shown in Figure 2. The average ranking of the class after having participated

in the four units is 2.86 out of 5, with 57% of males and 17% of females ranking this as a first or second choice elective. Only 5% of total respondents would not want to take the elective at all, which is a great improvement from the 30% who originally ranked the elective as a 0.

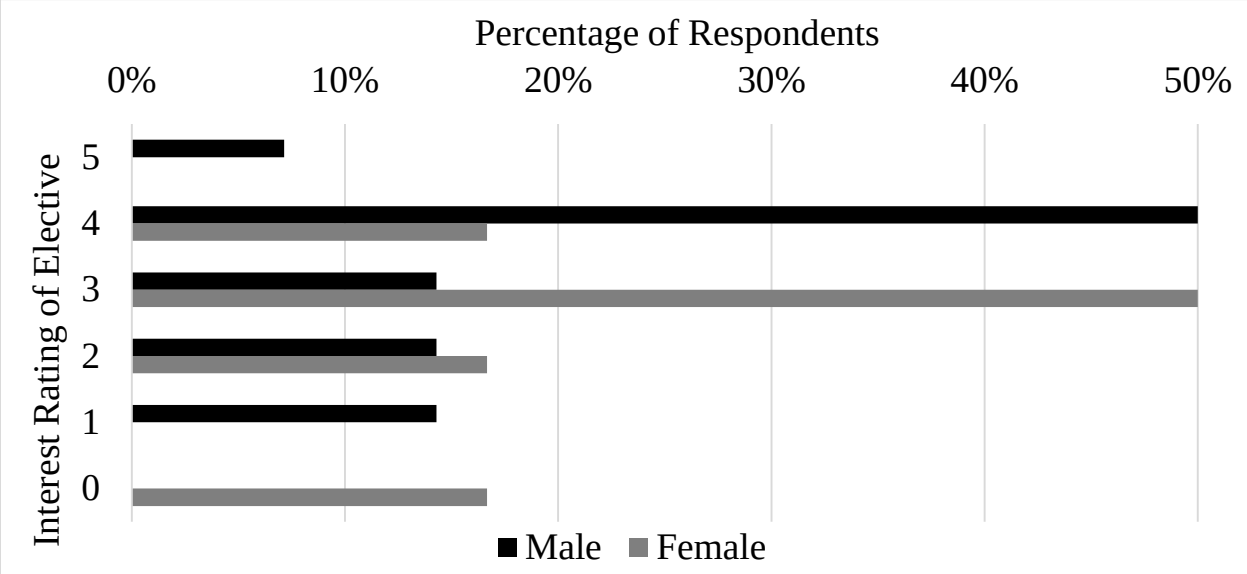

Figure 2 Final desirability ranking of robotics elective among students

Figure 3 shows the response of the students to the question of how interested they were in each topic after completing the unit compared to their initial interest. Most students were more interested in the topic or had no change in opinion after completion of the activities. The electrical circuits unit showed the greatest increase of interest among the students, but there were some differences when this information was further broken down by gender and ethnicity.

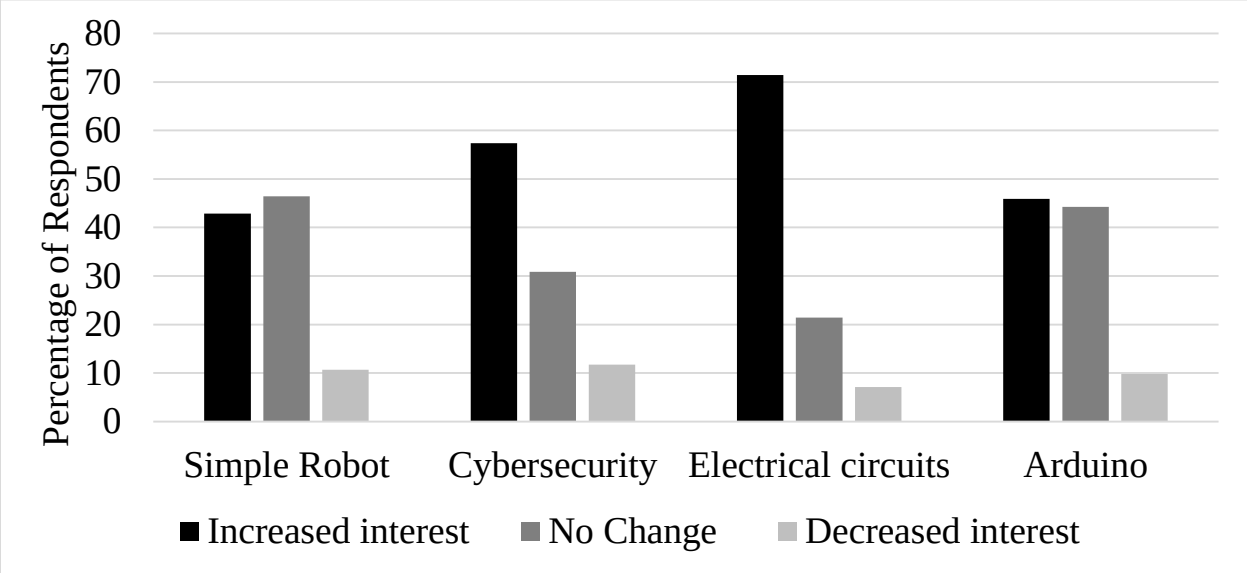

Figure 3 Student interest in continuing to study topic after completion of unit

Figure 4 breaks down the positive responses to each topic to show which units increased interest among different genders. The cybersecurity unit was the most successful at increasing interest among young women, while the electrical circuits unit had the largest positive impact on young men. After each unit, students were asked to rate their favorite activities within the unit and also to order those activities based on level of difficulty. Although there was little correlation between favorite activity and level of difficulty, there was evidence to show that students were more engaged when they were working towards a self-designed challenge, such as winning robot wars, creating a robot with synesthesia, or creating an Arduino prototype to address a challenge in their lives. Over half (54%) of students preferred working on their own challenges, with only 8% preferring the teacher assigned topics and the rest of the students having no preference.

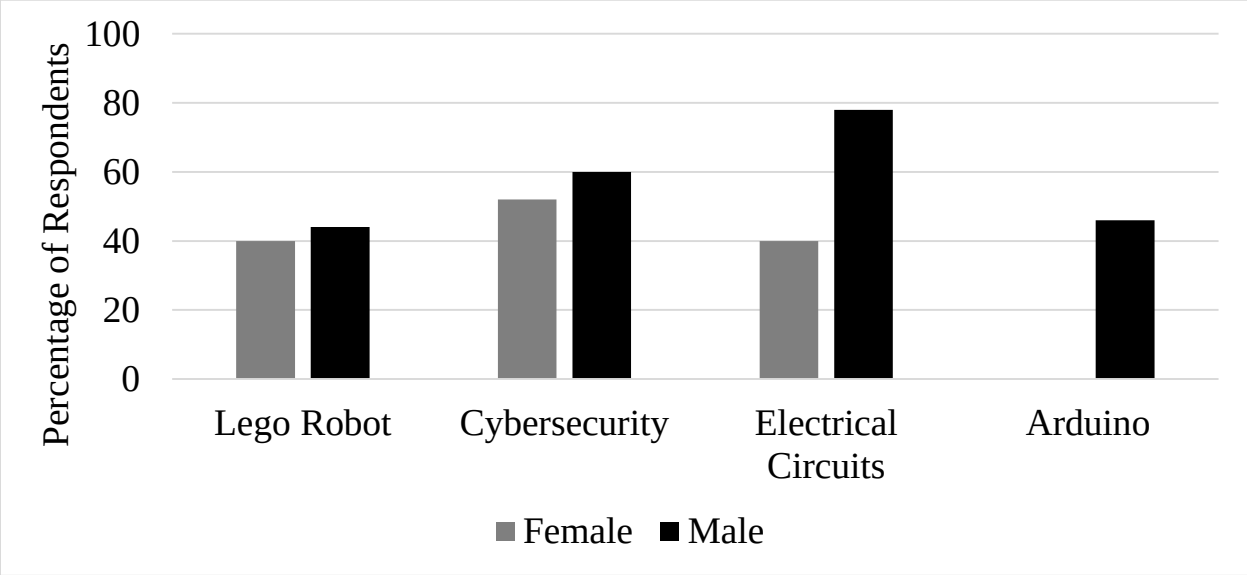

Figure 4 Desire to continue studying each topic broken down by gender.

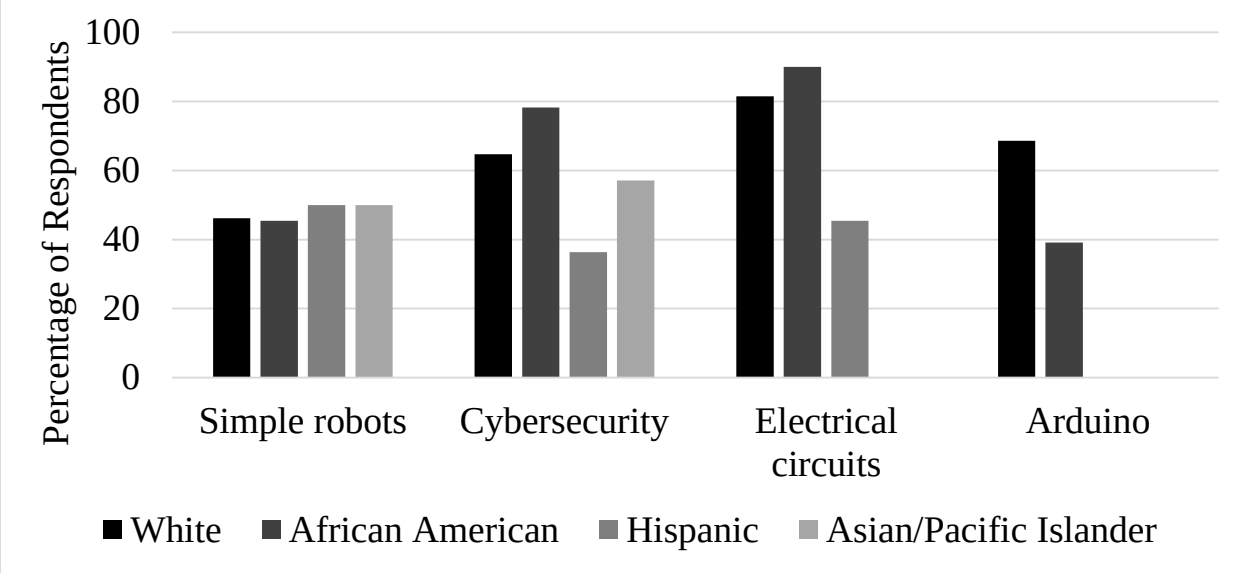

Figure 5 Desire to continue studying each topic broken down by ethnicity

Figure 5 demonstrates the increased interest in each topic based on ethnicity. The simple robot unit had an almost identical response across the ethnicities polled, with approximately 50% of respondents having increased interest in the topic. The other units varied in popularity with different ethnic groups. These preliminary results show some evidence that demographics play a role in increasing interest in each individual topic as there were variations in how students from different ethnic groups and genders responded to each of the different topics. However, with such a small sample size it is difficult to rule out other factors.

To separate out "the teacher effect", students were asked to evaluate the teaching methods used and how it affected their learning. The responses over all the units were averaged and it was found that, 86% of total respondents believed that the teaching methods were effective at enhancing their learning, 12% were neutral, and 2% thought the teaching methods were ineffective. Figure 6 shows the overlap of student responses to the effectiveness of teaching methods for enhancing their learning and interest in continuing to study robotics after completing the unit activities. This figure shows some correlation between the student's opinion of the teaching methods and interest in the topic. However, many students who considered the teaching methods to be effective had decreased interest, while some who thought the teaching methods were ineffective had an increased interest and a desire to continue studying the topics.

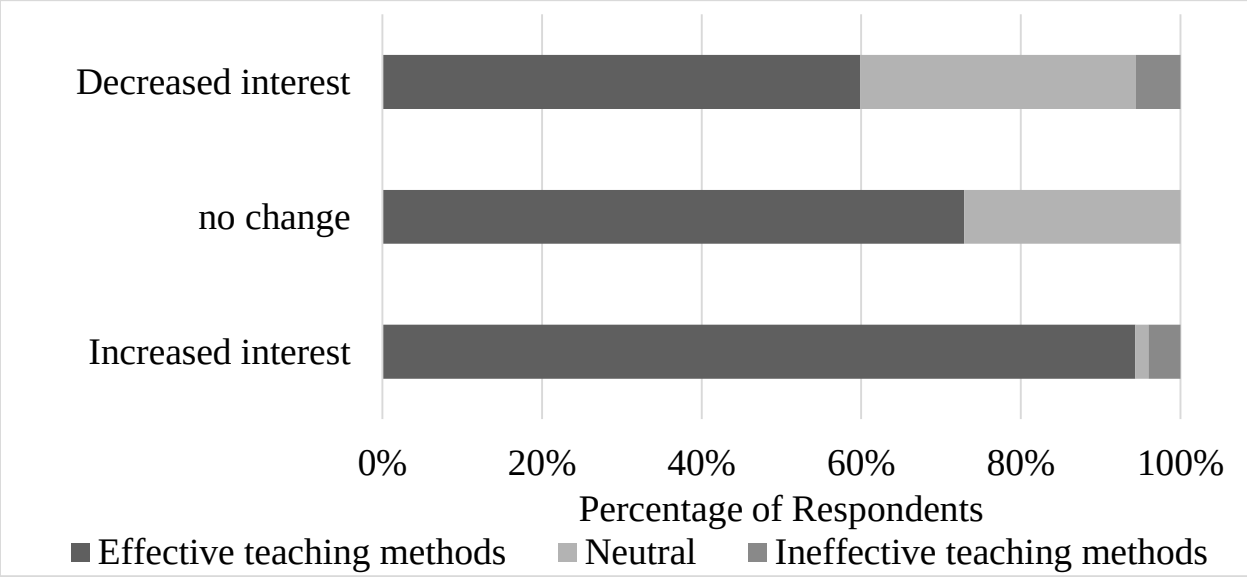

Figure 6 Impact of the teacher effect on student interest in studying robotics averaged across the four robotic units presented

In this group of students, the teacher effect did not seem to play a large role in how interested students were in each topic. When the information was further broken down by gender and ethnicity there were some trends suggesting that teaching methods have a greater impact on certain demographic groups. However, due to the small sample size certain demographic groups are represented by one or two students, these results may be student dependent and are therefore not included in this paper. However, the preliminary results have raised new questions about the role of demographics in student engagement. Does the teacher effect have a greater impact on certain demographic groups than others, and if so, how can we tailor the curriculum and train teachers to engage a diverse classroom?

In further studies, these questions can be explored in a variety of ways. The robotics curriculum could be introduced to multiple, diverse classrooms with teachers employing different teaching styles. Another option is to gather data from a single teacher using the robotics curriculum in multiple classrooms and/or over multiple years. The second option would need to be implemented in a school like SLA with a diverse student population and would take much more time than the first option. However, either study organization would help determine connections between teaching methods, demographics and student interest in continuing to study STEM topics.

Conclusions and Future Work

This work in progress has provided preliminary data and a methodology for studying the role of demographics in a STEM based classroom employing constructivist pedagogy. The small sample size prevents decisive conclusions about the influence of demographics on student engagement. However, initial results demonstrate the value in continuing the study as trends lending support to the role of demographics on student engagement have already arisen in this data. Additionally, questions not initially considered arose based on the results, such how teacher influence affects engagement among different demographic groups. Suggestions on how to study these factors and separate demographic influence from the teacher effect are given throughout the paper.

Acknowledgments

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