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Incorporating Engineering Programs for Secondary Schools in Trinidad and Tobago (Work in Progress)

Miss Tasha Tiffany Tardieu, University of Michigan

Recent graduate of the University of Michigan, studied Civil Engineering with an International Studies Minor for Engineers. As a student in the College of Engineering's Honors Program, I investigated the incorporation of co-curricular engineering programs at the upper secondary school level in Trinidad and Tobago for my capstone project. This project will be continued beyond my undergraduate career.

Dr. Shanna R. Daly, University of Michigan

Shanna Daly is an Assistant Professor of Mechanical Engineering at the University of Michigan. She has a B.E. in Chemical Engineering from the University of Dayton (2003) and a Ph.D. in Engineering Education from Purdue University (2008). Her research focuses on strategies for design innovations through divergent and convergent thinking as well as through deep needs and community assessments using design ethnography, and translating those strategies to design tools and education. She teaches design and entrepreneurship courses at the undergraduate and graduate levels, focusing on front-end design processes.

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Introduction

Since its independence in 1962, Trinidad and Tobago has striven to increase the standard of education locally and regionally in the Caribbean. In 2012, the literacy rate in the country was 99.58% which is the highest in the Caribbean and one of the highest in the world[1]. Additionally, primary and secondary education is free for all students and tertiary education is highly subsidized for all qualified students at local and regional institutions. Despite these efforts to focus on education, Science, Technology, Engineering and Mathematics (STEM) education is not considered an important area of focus at the primary or secondary level, especially Technology and Engineering. There is a need for more project-based and applied learning in these fields in order to expose students to the possibilities of an engineering career.

In the United States, there is a push to increase enrollment in STEM majors and this trend is no different globally. In the Caribbean, at the University of the West Indies the number of STEM graduates compared to other degree levels was significantly lower in 2012 and furthermore the number of graduates in the Engineering Faculty was the only one to decrease from 2008 to 2012, as well as being one of the lowest number of total graduates, second only to the Faculty of Law[2]. Also, similar to the United States, there is a stark difference in the number of female engineering students compared to male engineering students. While the female enrollment at Caribbean campuses is usually three times more than male enrolment, engineering is the sole exception with 62% of students being male during the 2012-2013 academic year.

However, unlike the United States where there are a variety of pre-collegiate programs for middle and high school students, that is not the case in the Caribbean, and especially Trinidad and Tobago. There are over 200 secondary schools throughout the country but in a 2015 bridge building competition, only 32 schools participated. Additionally, Trinidad and Tobago took part in the 2015 Sagicor Visionaries Challenge that is sponsored by the Caribbean Science Foundation with only 6 entries compared to over 20 entries from other competing Caribbean nations. This needs to change as Trinidad and Tobago is one of the leading developing nations in the Caribbean and there is an important link between science and engineering, and regional economic development[3]. Reynolds et al. found that "introducing engineers to children as people who solve everyday problems has been correlated with interest in engineering careers, an experience using engineering design to solve everyday problems appears to reinforce that perception and increase interest in engineering careers"[4].

Thus, the goal of our study was to evaluate interest and potential benefits of exposing secondary school students to practical engineering experiences. We investigated current knowledge of engineering at the secondary school level in Trinidad, the level of student interest for additional engineering activities, and types of engineering fields that are most appealing to students. Surveys were administered to current secondary school students in Trinidad and Tobago to gauge their exposure to various engineering fields as well as to post-secondary students who attended school in Trinidad and Tobago and chose to pursue engineering. Next steps in our work will explore current levels of exposure to engineering at the secondary level and propose models

for integration of practical engineering experience into the existing educational structures as our broader goals are to support interest and pursuit of STEM fields by students in Trinidad and Tobago and prepare them for the engineering undergraduate environment and curriculum.

Research Design

Research questions guiding our work included: 1) To what extent are secondary school students in Trinidad and Tobago exposed to engineering as part of their school curriculum?; 2) How does the current level of exposure relate to students' interest in undergraduate engineering studies?; and 3) How well do current engineering undergraduates who attended secondary school in Trinidad and Tobago think their education prepared them for engineering?

Participants in the study included a sample of secondary school students in Trinidad and Tobago and students from Trinidad and Tobago who pursued engineering degrees (Table 1).

Table 1. Participant Demographics

Students who pursued Engineering					**Current Secondary School Students**			
Gender	**Male**	**Female**			**Male**	**Female**		
	56%	44%			38%	62%		
Age (years)	**18-20**	**21-23**	**24+**		**<14**	**15-16**	**17-18**	**18+**
	0	75%	25%		35%	26%	34%	5%
Student Status	**Student**	**Non-student**	**Other**		**Forms 1-2**	**Form 3**	**Forms 4-5**	**Form 6**
	63%	25%	13%		35%	0	20%	46%

Data were collected from online and paper surveys. The survey administered to current secondary school students was distributed by asking teachers at two schools to distribute the surveys to at least 50 of their students. One of the schools was an all-female school and the other was an all-male school, both located within 3 miles of the capital city of Trinidad. While the researchers specified that a range of grade levels would be most beneficial, surveys were distributed at the discretion of the schools' teachers. A total of 93 responses were collected. Sixteen responses were collected in a separate survey distributed to students from Trinidad and Tobago who pursued engineering, recruited from the researcher's network.

Quantitative data were analyzed with descriptive statistics and qualitative data were analyzed by grouping answers into broad categories for open-ended questions in order to capture an overall sense of participant results. Table 3 shows a cross section of the questions of each survey.

Table 3. A Sample of Survey Questions

Current Secondary School Students survey		Peer survey	
Q.4	When working through a Math problem, how excited do you typically feel after you have solved it? (5=very excited, 1=very bored)	Q.3	Are you currently a student in engineering?
Q.5	How interested are you in the way things work (5=very interested, 1=not interested at all)	Q.4	If you are no longer a student, are you working in an engineering related field?
Q.7	Have you ever learned about engineering?	Q.7	Why did you choose to study engineering?
Q.8	What do you think an engineer does in his/her job?	Q.9	How did your prior experiences or lack thereof impact your undergraduate experience?
Q.9	Please select the types of engineering that you have heard of? (15 options given, with an "Other" option)	Q.10	Do you believe there is any benefit to offering hands-on engineering programs to interested secondary school students? Why or why not?
Q.10	Would you be interested in learning more about engineering through an extra-curricular project?	Q.13	Do you have any suggestions for implementing such programs?

Results

Out of the 92 responses received for the question "Have you ever learned about engineering", there were an equal number of students who had learned about it, who had not learned about it and interestingly, who were not sure whether they had or had not (Figure 1). 43% of students are very interested and 34% of students are interested in the way things work, which is a foundational interest of the engineering profession. However, despite the lack of exposure that these results indicate, 40% of students agree and 29% strongly agree that they enjoy designing something new or different and, 45% agree and 30% strongly agree that they enjoy building objects, both of which are traditionally considered engineering-related activities (Figure 2). Furthermore, more than half of the participants stated that they would be interested in learning more about engineering through an extra-curricular project.

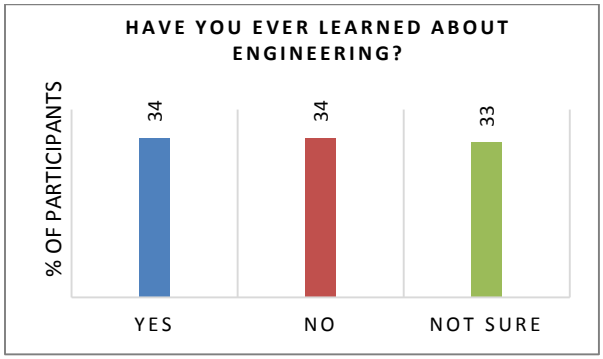

Figure 1 Students who have learned about engineering

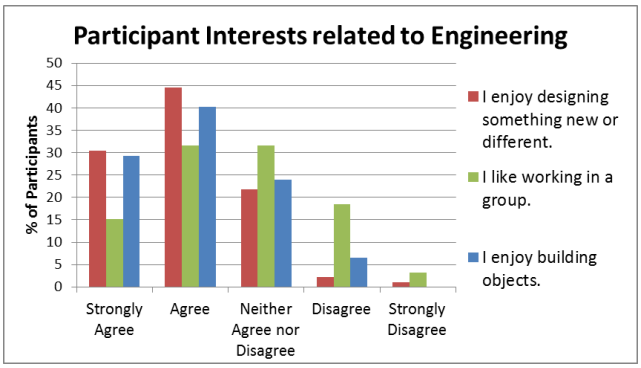

Figure 2 Student interest in engineering activities

A similar trend was evident with regards to learning about engineering at the secondary school level from the responses of peers who have pursued engineering in college. While over 70% of participants had a teacher who spoke about engineering in classes, 66% had not been exposed to any other engineering activities or lessons in engineering during secondary school (Figure 3).

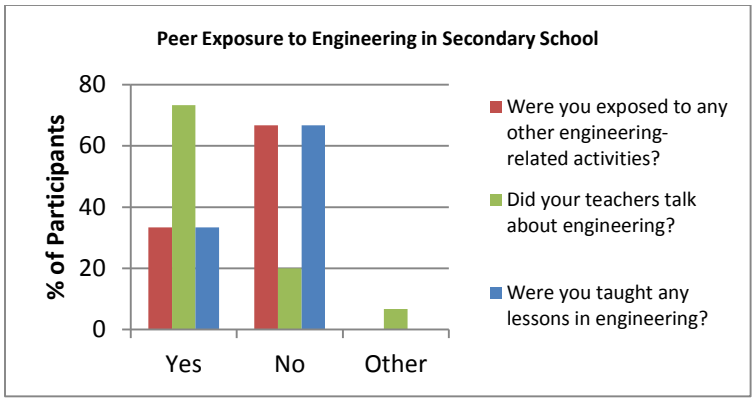

Figure 3. Level of Exposure of Peers to Engineering during Secondary School

When the current secondary school students were asked to define the work of an engineer, most students associated it with the actions of "build/make", "fix/maintain" or "design/create/invent"; however, most students only had a general idea of what engineers work on (Table 4).

Table 4. Q.8.What do you think an engineer does in his/her job?

Action	**Number**	**Object**	**Number**
Build/makes	35	Cars	2
Fix/maintain	19	Buildings/bridges	8
Design/create/invent	43	Engines	1
Draws	1	Circuits/Electrical	1
Develop solutions	10	Lives/society	11
Not sure	1	Machines	7
		Oil	2
		Devices/Technology	5
		Things/Objects/Stuff	48

When peers were asked to consider why they chose to study engineering, 38% of them stated a passion for designing, problem solving and hands-on projects drew them to the field. 19% stated that an aptitude for math and science in school made them think that engineering would be a suitable match for their knowledge. With the responses seen above in Figure 3, peers were asked to elaborate on how their level of prior exposure impacted their undergraduate experience. The general response appears to be that approximately 38% felt adequately prepared by the rigor of the secondary school curriculum but 44% felt unprepared compared to peers due to a lack of exposure to technical classes and hands-on engineering projects and activities. At the same time, 100% of peers surveyed believe that there is benefit to offering a hands-on engineering program to secondary school students in Trinidad and Tobago, based on their own experiences.

Discussion

Survey results indicated that those students in Trinidad and Tobago had limited exposure to practical engineering experience as part of their school curriculum. While students are aptly prepared in the theory of Math and Physics, they are not allowed many opportunities to apply these concepts to design problems or to relate these ideas to real-world applications. This especially seems to be an issue in all female secondary schools since 50% of peers suggested that there be a focus on teaching girls about engineering.

According to peers, while a majority felt adequately prepared for the college level workload because of their secondary school education, many felt that there could be a greater level of preparation by exposing students to the practical side of engineering. 27% of the students wanted to find out more about engineering, the different types of engineering and what an engineer does in his profession. It appears that while students have heard about engineering, they do not know the specific tasks of an engineer or what the profession is responsible for specifically. As a result, students at the secondary level do not understand the expectations of pursuing an engineering degree at the college level before they are made to choose a particular academic focus area.

According to peers, there are multiple benefits to introducing a hands-on engineering program to secondary school students. Firstly such a program should give secondary school students better college and career choice preparation by imparting knowledge of the engineering field that is currently unavailable in their studies. From their own undergraduate experience peers have found that practical knowledge is essential for engineering studies and believe that such a program can provide students with necessary skills needed to pursue engineering such as reasoning and practical thinking.

Both peers and current secondary school students were asked to provide recommendations for the components of a possible program as well what age group will most benefit from this particular kind of program. An equal number of peers thought that the program would be suitable for students in Form 3, usually ages 14-15 years, and students in Forms 4 and 5, usually ages 15-17 years. Additionally, more than half of the respondents suggested design projects such as bridge building, plane modeling, robot design and coding. Others also promoted the inclusion of non-design activities such as site visits, presentations on the various fields of engineering, films and lab work. These recommendations coincide with what current secondary school students would want to include in the program such as job descriptions of types of engineers, design-build projects and specific topics of study such as computer science and electrical engineering. These recommendations will be beneficial as we move into the next stage of this project, which is to design a suitable program for secondary school students since it is clear that students are interested and there would be a benefit to students to be offered such an opportunity.

Conclusion

This study aimed to investigate the level of exposure of secondary school students in Trinidad and Tobago to the engineering profession and related activities. Additionally, the study sought to find out if there is any interest in learning about engineering among secondary school students. From the research conducted, it was found that students do not have much opportunity to explore engineering at the secondary school level but that there is an interest in a program that allows students to do so. Furthermore, it was found that the lack of prior engineering experience does affect students' transition into undergraduate engineering students. From the results of this study, we hope to design a curriculum that is tailored to meet the interests of the students, while using locally available resources. It is the goal of this potential program that students will be more informed about the engineering profession and promote interest in pursuing an engineering and technology career in the future.

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