

Board 79: Experience from S-STEM Project: Engaging Undergraduate STEM Students with Prototype Development Projects

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Abstract

The S-STEM Collaborative Research: Making to Advance Knowledge, Excellence and Recognition in STEM (MAKERS), award received in 2016 from the National Science Foundation (NSF) offered a scholarship to about thirty STEM students majoring in Mechanical Engineering, Electrical Engineering, Civil Engineering, Construction, Computer Science, Biology, Chemistry, Physics, and Mathematics at Alabama A&M University. As part of the requirements of the scholarship, the students have been involved in a group prototype development projects primarily initiated by the team members under the supervision of faculty mentors. Currently, there are five prototype projects with five to eight team members per project. The team members and the faculty advisors of each project meet periodically to discuss the progress of their project, share their experiences and the challenges they have faced. In addition to the financial support provided to the students, the S-STEM funding received from the NSF provided the students with opportunities to attend graduate resources fair sessions conducted in the neighboring institutions, work together and develop a teamwork approach in brainstorming and solving technical problems. In this paper, we will present our experiences working on the NSF funded S-STEM project, the list of the students' prototype projects, the challenges we faced and the objectives accomplished.

Introduction

The five years S-STEM, NSF-funded program is the result of the efforts put together by six partner institutions. The primary goals of the project are to increase both the retention and graduation rate of academically talented, financially disadvantaged minority STEM undergraduate students, and to prepare them joining the STEM workforce and earn advanced degrees in a STEM discipline. The S-STEM program at Alabama A&M University gave hands-on experience to many of the participants with little or no prior exposure to teamwork and hands-on activities. To those who already have experienced, the activities enhanced their hands-on, teamwork and networking experiences.

In order to be eligible for the NSF sponsored MAKERS scholarship program, a student must be a U.S. Citizen or permanent resident, STEM major enrolled fulltime with a GPA of at least 3.00/4.00, and should be able to provide documentation showing financial needs. Based on these criteria, the program activities were started in fall 2017, with twenty qualified and deserving STEM majors. So far four scholars have received their undergraduate degrees in Biology, Mathematics, Physics, and Construction. Currently, there are thirty scholarship recipients

majoring in Biology, Physics, Chemistry, Mathematics, Construction, Computer Science, Civil Engineering, Mechanical Engineering, and Electrical Engineering. As the students are recruited from all STEM discipline, the project activities are not associated with any of the course curricula. However, being part of the prototype project activities has its own positive contribution on the students' social and technical skills in providing the students with the opportunities to adopt Blooms Taxonomy [1] in applying innovative thinking and brainstorming sessions to evaluate the idea analyze alternative approaches and designs. The project also created a collaborative working environment, where the teams meet periodically to discuss their projects, and get feedback from the mentors and students working on other projects, and accomplish the goal of the prototype development project. Encouraging students to work in teams in product design and manufacturing is believed to have a positive impact in enhancing students learning outcomes [2].

Research on project-based learning indicated that students involved in project activities learn and conceptualize engineering principles and designs more favorably than the traditional classroom-based learning [3-7]. The authors also pointed out that team projects encourage creativity, and are more interesting and engaging to the students. Targeted and competitive scholarship programs and involving undergraduate students in research and group project activities also have a considerable impact in improving retention and increase the likelihood of entering the STEM profession and joining graduate studies [8-11]. This extracurricular group prototype development activities also encourage a 'design thinking' [7] approaches, enriches their hands-on skills and overall learning experiences [4], which also created a platform for learning the processes of multidisciplinary team building, brainstorming and generating ideas, conceptual design, and prototype development [6].

Project Activities

The primary goal of the prototype development is to involve and encourage teams of undergraduate STEM students initiate project ideas, design the prototype of their choice, and produce the device. Each team is composed of STEM majors with diverse background and classifications (freshmen to senior students). In addition to the faculty mentor, each team has a student team leader who has a responsibility in coordinating the team, schedule project meetings and leads the prototype project activities. Even if the majority of the students did not have prior hands-on experience, there are some who have remarkable entrepreneurship vision and ability to generate marketable ideas.

The total number of students responded to the survey were twenty-two, majoring in diverse areas of STEM discipline including civil engineering (N=1), mechanical engineering (N=4), electrical engineering (N=6), Computer science (N=3), biology (N=3), and physics (N=5). The student classification covers freshman (N=5), sophomore (N=6), junior (N=7) and senior (N=4). Among the 22 students responded to the survey, 16 of them are also receiving other scholarship, and 13 of them have tuition scholarships. Five different prototype projects were initiated including developing Apps, energy harvesting devices, recyclable shower, plastic recycling system, e-bike.

Each team is composed of students across STEM disciplines including life and physical sciences, computer science, and engineering. The project provided a financial scholarship to the students, and funding for supplies and material need to produce the prototype and travel expenses to attend the annual STEM conference, where they can showcase their works.

Preliminary Findings/Results

To understand and assess the students' perception of the projects' activities and the impacts it has on their social skills and solving challenging technical problems, anonymous survey questions were distributed. The results of some of the responses are summarized in Figure 1. As can be seen in the Figure, no response is recorded indicating that the students strongly disagree or disagree on any of the five questions summarized in the Figure.

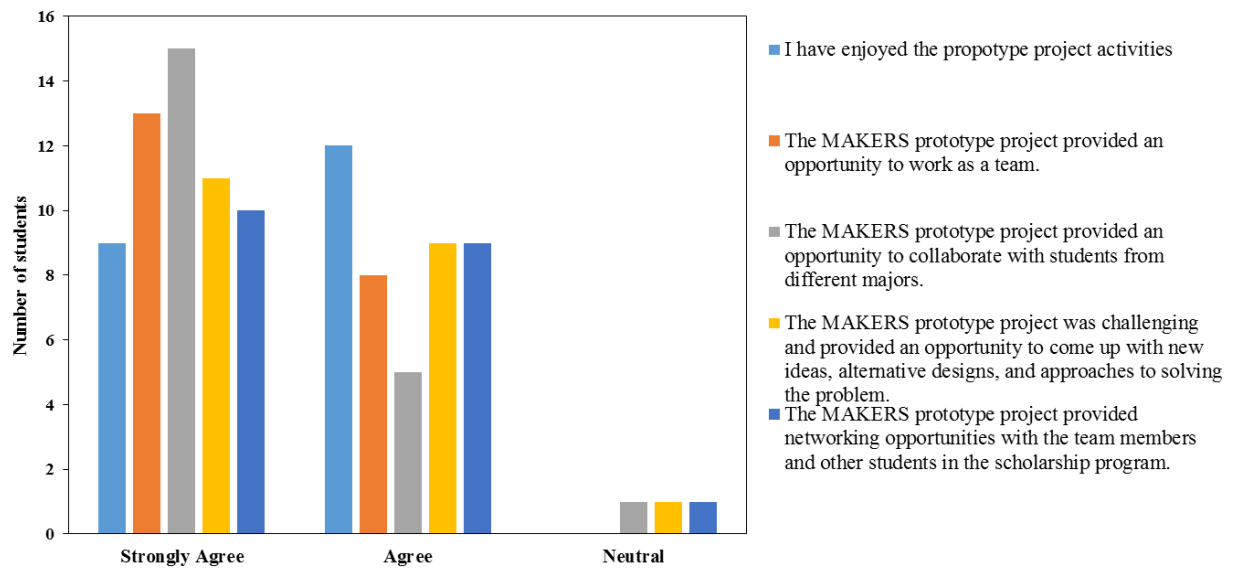


Figure 1. The students' level of agreement to the five survey questions shown in the legend.

To assess whether the students have enjoyed the project or not, among the 22 students responded to the survey, 41% of them strongly agree that they have enjoyed the prototype development project, and 59% of them agreed. For this question, no response is recorded under neutral, disagree and strongly disagree. Unlike group-project activities incorporated under some of the engineering curriculum, which is composed of students with the same major discipline and classification and typically lasts a couple months or the formal senior capstone design projects which extend throughout a semester or two of the students' senior year, the MAKERS prototype development team are composed of students from diverse background and classification working towards a specific goal. All students are required to actively participate and contribute to the project, attend periodic meetings, and present the prototype development project at the joint annual STEM conference of all the participating institutions. The prototype development project

provided the students with an opportunity to create a team-work environment from initiating a project idea through the various phases of product design and development. The results of the survey indicated that 59% of the students strongly agreed, and 36 % of them agreed that MAKERS project provided them with an opportunity to work as a team, which they may not have otherwise. This project also facilitated the cross-disciplinary collaboration of undergraduate students. The results of the survey, which indicated that about 87% of the students are well in favor of the prototype project's significant contribution in creating a collaborative platform for them to work with others from diverse background and classification. The project activities enhanced the students' networking opportunities, communication and presentation skills [12]. Regarding the students' experience on the level of difficulty of the selected team projects, about 91% of the students participated in the survey responded that the project is challenging and being part of the team encouraged them to come up with new ideas, alternative designs, and approaches in solving technical problems.

Conclusions

This paper reports the experiences and the positive impacts of the NSF-MAKERS program at Alabama A&M University. The project recruited more than thirty qualified and financially challenged students from all STEM disciplines. In 2017/18 academic year, there were five separate teams with five different prototype development activities. The preliminary works of the teams were presented at the annual STEM conference held with the partnering institutions. In this academic year, one more project which will heavily utilize 3D printing technology. As indicated in some of the survey responses, the MAKERS program opened up opportunities and encouraged students to work as a team to successfully accomplish a common goal of initiating, brainstorming and building a feasible prototype. Working in teams is rewarding in terms of enhancing students' experiences, facilitating technical exposure to students with different classification and major areas forming an effective team. In addition to mentoring and involving the students in hands-on project activities and preparing them to join the STEM workforce, or pursue graduate studies in STEM, the scholarship program provided financial support to all participating students. This close interaction between the mentors and students and the financial support have a positive impact on improving retention and graduation rates of the underrepresented minority students. The survey data collected suggest that group prototype project provided opportunities to work as a team with cross-disciplinary major and classification and enjoyed working in a team setting than the individual project.

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