Impact of Engineering Ambassador Program on Academic Attainment of Minority Students in Engineering

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Abstract

In this paper, the impact of the Engineering Ambassador Program (EAP), which engages undergraduate engineering students as Ambassadors in K-12 outreach activities, on the stimulation of interest in STEM, self-efficacy, and actual academic attainment of Ambassadors is presented. The collected data over several years reveals that over 2/3 of activity leaders and project coordinators of the EAP at Howard University (HU) expressed higher confidence in their ability in understanding and succeeding in engineering because of their EAP experience. Also, the activity leaders and project coordinators achieved higher major and overall grade point averages (GPAs). Furthermore, improved academic performance in the courses related to the projects that Ambassadors were exposed to such as hands-on earthquake and coastal engineering projects was attained. Lastly, the Ambassadors exhibited a shorter time to degree completion with their peers who did not participate in the EAP.

Introduction

The Engineering Ambassador Program (EAP) was incepted in 2009 as a professional development program for undergraduate students in engineering disciplines with an outreach mission to the K-12 students for presenting what engineers do [1, 2]. Studies have shown that the knowledge of students about a field of study is the key factor that influences their interest in considering a major [3,4]. The program has since expanded and is administered in multiple institutions. The program has also exhibited significant positive impacts on college student development and on eliciting much interest from the K-12 students and teachers. The EAP participants have expressed gains in soft skills, confidence in abilities to succeed in engineering, and an increase in the self-perception as skilled leaders [5]. As the ambassadors engage on carrying out the critical mission of serving the EAP, they develop the necessary communication skills and technical competencies for presentations and mentoring activities. This engagement and skill development increase the interest and confidence in STEM education, especially during the early years of undergraduate education through the exposure to engineering challenges that show the real-world relevance of science and engineering. Also, through mentoring in outreach programs and platforms, the ambassadors both exude and experience an inculcation of enthusiasm which is known to be a key element of fueling the interest in STEM education [6]. These professional development and outreach attributes were the primary goals and benefits of the EAP.

The professional development and increased interest that ambassadors experience during the EAP participation can have a longer-term influence on their academic performance. In addition to going through the training process for the EAP projects, the ambassadors also gain hands-on
experience in various stages including the design process and the implementation stage. This is consistent with the findings in the literature that the “learning by doing” approach through hands-on experience projects, which is exercised during the EAP activities, is a key factor in better learning and improved academic performance [7]. The literature extensively underlines the positive impacts of hands-on educational and research activities on higher graduation rate in STEM disciplines [8, 9]. Interestingly, the positive effects of such activities have been reported to be strongest among minorities such as Affrication American students [10, 11]. The survey data collected from two EAP program participants, one in a predominately white institution and the other in a Historically Black College and University (HBCU), also revealed that the improvement in some attributes such as confidence in the ability to succeed in engineering was markedly higher in the HBCU program [12].

The benefits of the EAP on the academic performance and attainment of participating ambassadors have not yet been addressed in the literature. The academic performance in specific courses that may be related to the EAP projects, the overall grade point average (GPA), and the graduation rate are of interest in this paper. The hypothesis is that the higher level of confidence and interest in ambassadors along with the faculty/ambassador mentoring relationship, and the preparatory training of ambassadors enhance the academic performance of the ambassadors. In this paper, the impact of the EAP on the academic performance and attainment of the participating ambassadors at HU is studied.

**EAP at Howard University (HU)**

The EAP at started in 2011 in collaboration with the Network for Earthquake Engineering Education (NEES) and an NEES associated State University. The undergraduate student ambassadors in the College of Engineering and Architecture at HU utilize hands on experience projects to educate children and families about tsunamis, earthquakes, costal and earthquake-structural engineering in the metropolitan area. The initial objective of establishing this program was to lead an outreach activity at National Engineering Week family day in the city, which usually hosts over 9,000 children. The program successfully expanded its scope and the engineering ambassadors have participated in numerous large- and small-scale outreach events in the past several years.

The EAP currently runs two hands-on outreach activities; a mini wave structure challenge and a mini-shake table structure challenge. These two activities are composed of three stations: demonstration/introduction, building/construction, and testing. In the mini-wave flume structure challenge shown in Fig. 1, the ambassadors provide children and families a basic introduction to forces on a structure, hydraulic pressure, and a quick problem solving activity. This activity utilizes a 16-foot long mini-wave flume. In this project, the ambassadors teach children and families about tsunamis and their effects on structures and about the role that engineers play in the preparedness for extreme events such as a tsunami. The activity provides children and families the opportunity to build a LEGO structure from the provided supply and later to test the safety of it under the hydraulic force in the mini-wave flume. The ambassadors provide the logistics, transport and set
up the flume and materials, interact with the activity’s participants, and introduce the general role of coastal engineers and how engineers design structures to protect people life. The ambassadors guide the participants during the different stations of the activity, building the structure and later testing it in the flume. In the shake table challenge, the ambassadors teach youth participants and families about earthquakes, their impact on structures, and the role that engineers have within earthquake engineering. This activity utilizes a small earthquake simulator for demonstration, and a hand-held shake table for testing as shown in Fig. 2. During the training, the ambassadors themselves learn basic principles about wave forces, aerodynamic shapes, tsunami waves, structural design to withstand wave impact, seismic waves, and stability and survivability of structures.

A faculty mentor administers the EAP at HU. The faculty mentor provides general guidance, communicates with the sponsor, manages resources, and serves as an advisor. However, the ambassador program functions as a self-managed team with characteristics of a student organization under the lead of a student coordinator. The coordinator recruits team members based on their interest and willingness to commit the required time to the activities. As such, the selection of EAP participants is a volunteer/self-section process.

![Fig. 1: Schematic of the mini-wave flume (a), and participating youths during testing (b)](image1)

![Fig.2: Schematic of the shake table (a) and participating youths during testing (b)](image2)
From the faculty perspective, this program provides the opportunity to: interact with the students outside of the classroom and in different environments, identify students’ skills, use out-of-classroom activities to develop students’ communication and teamwork skills, provide experience in public relations (meeting people, public speaking, representing the university, etc.), which enables ambassadors to feel more "connected" to their role in society as engineers, and identify potential students for undergraduate research activities.

Results

Demographic of Participating Ambassadors

The number of participating ambassadors have steadily grown from 12 in 2011 to 37 in 2016. During the sixth years of the EAP, there was a total of 158 ambassador participants. Table 1 shows the demographic of participating students during the 2013-2016 period for which the academic performance data in this paper is presented.

Table 1 – Demographic of Participants in the EAP Program

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of participants</td>
<td>24</td>
<td>30</td>
<td>35</td>
<td>37</td>
</tr>
<tr>
<td>Black/African American</td>
<td>24</td>
<td>30</td>
<td>34</td>
<td>35</td>
</tr>
<tr>
<td>Latina/Latino/Hispanic American</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Asian</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Have earned a BS degree</td>
<td>20</td>
<td>24</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

Fig. 3: Results of survey of 34 EAP participants who strongly agreed or agreed to the questions
**Ambassadors Surveys**

Overall, participating in the EAP at HU had a positive impact on students’ perception of their abilities and confidence. Approximately 2/3 or more of students indicated that they feel the program improved their interest in engineering disciplines, confidence in ability to succeed in engineering, increased technical knowledge and understanding of engineering, and communication skills for technical concepts. Fig. 3 exhibits the response of 34 participants in the EAP who answered strongly agree or agree to the survey questions.

**Academic Performance**

The academic performance of EAP and non-EAP students in Civil and Environmental Engineering (CEE) was studied using the available grade and transcript information for 10, 8, 13, and 16 students in 2013, 2014, 2015, and 2016 years, respectively. Therefore, the presented results in this section is the analysis of the academic record of 45 students, 28 of which were participating ambassadors in the EAP. The average of GPA in CEE courses is depicted in Fig. 4. The GPA of EAP participants is higher compared with that of non-EAP participants. Similarly, the overall GPA in all courses in shown in Fig. 5 which is also higher for the EAP participants.

![Graph showing academic performance of EAP and non-EAP students](image)

*Fig. 4: Average of GPA of EAP and non-EAP students in Civil and Environmental Engineering courses. The ratio of EAP students to all students were 7/10, 6/7, 11/13, and 4/15 for 2013, 2014, 2015, and 2016.*
Fig. 5: Average of overall GPA of EAP and non-EAP students in all courses. The ratio of EAP students to all students were 7/10, 6/7, 11/13, and 4/15 for 2013, 2014, 2015, and 2016.

Fig. 6: Average of students grades in Structures I in the CEE curriculum. The ratio of EAP students to all students were 7/10, 6/7, 11/13, and 4/15 for 2013, 2014, 2015, and 2016.
One of the individual courses in the CEE is Structures I (CIEG 314, an introduction to structural analysis) which has some common topics as those discussed in the projects of the EAP activities. The ambassadors have shown a better performance in the course and the average of the final grades in the course, as shown in Fig. 6, validates this assessment. The graduation rate, measured by the years for the bachelor’s degree completion, is presented in Fig. 7. The EAP students finished their bachelor’s degree in CEE in sooner or at least equal time, compared with the non-EAP students.

Discussion

The analysis of the academic record of the students, EAP and non-EAP students, points to the view that participation in the EAP program is related to higher academic attainments in coursework related to the EAP activities and in the overall grade point average. This is an intriguing attribute of the EAP that might not have been studied before. However, it may not be surprising, given the hand-on nature of the activities in the EAP at HU and the confirmation from the literature on the positive impact of the hands-on experience activities on student retention, especially among minorities [9-11]. Nevertheless, additional qualitative data and analysis from the students are required to explain how and what aspects of their EAP participation may have contributed in their academic growth.

Fig. 7: Graduation rate measured by the number of years for bachelor’s degree completion. The non-EAP students in 2014 were transfer students and the “time to degree completion” was not established. The ratio of EAP students to all students were 7/10, 6/7, 11/13, and 4/15 for 2013, 2014, 2015, and 2016.
One important note is that the presented data and results is a work in progress and the numbers may change over time as new data is obtained or previous data is better completed. As an example, a comparison between Fig. 3 in this paper and the data in Reference [5] reveals a discrepancy in the percentage of ambassadors at HU that expressed “confidence in ability to succeed in engineering”. Specifically, in this paper the corresponding number is 66%, whereas it was 83% in Reference [5]. The reason for this discrepancy is that the survey population in this paper is 34 and that of Reference [5] was 18. As the number of survey participant has increased, the responses are further averaged. Nevertheless, the general trend of the academic record seems to support the higher level of confidence and interest in ambassadors along with the faculty/ambassador mentoring relationship, and the preparatory training of ambassadors enhance the academic performance of the ambassadors. As this work is in progress, future data and academic record on current participants in the EAP and the control population will be gathered more accurately for validation and reevaluation of the assessment in this paper.

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