2019 HAWAII UNIVERSITY INTERNATIONAL CONFERENCES
SCIENCE, TECHNOLOGY & ENGINEERING, ARTS, MATHEMATICS & EDUCATION JUNE 5 - 7, 2019
HAWAII PRINCE HOTEL WAIKIKI, HONOLULU, HAWAII

EXPOSURE OF TRADITIONALLY UNDERREPRESENTED STUDENTS TO STEM RESEARCH AS INCENTIVE TO MAJOR IN STEM DISCIPLINES

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Synopsis:

The Program of Excellence in STEM (PE-STEM) at Florida A&M University (FAMU) is a program designed to address this issue, especially a Historically Black College and/or University (HBCU). PE-STEM in its sixth year and was specially designed to increase the number of traditionally underrepresented students recruited to, retained in, and graduating from STEM majors by participation in STEM-related research activities.

Exposure of Traditionally Underrepresented Students to STEM Research as Incentive to Major in STEM Disciplines

Abstract

Currently, underrepresented students in K-12 are not pursuing degrees in the Science, Technology, Engineering and Mathematics (STEM) disciplines at the rate of other groups. The Program of Excellence in STEM (PE-STEM) at Florida A&M University (FAMU) is a program designed to address this issue, especially a Historically Black College and/or University (HBCU). PE-STEM in its sixth year and was specially designed to increase the number of traditionally underrepresented students recruited to, retained in, and graduating from STEM majors. This endeavor includes exposing minority high school students to research in various STEM-related fields. The hands-on research activities, including mentoring from faculty and graduate students in these fields of study, has been noted to motivate minority students to select STEM disciplines in college and for careers. PE-STEM uses a nearly four-week long Summer Academy and monthly workshops throughout the academic year to provide students with the exposure and involvement in cutting-edge research to stimulate their interest in STEM. All of these activities were monitored to determine their actual effectiveness on the attitudes toward, participation in, and desire to pursue degrees in STEM-related fields in their future. Participants at the inception of the program initially stated their interest in STEM majors at around 55%, and after the 5 year mark the stated interest increased to over 90%. In addition, several factors and other data that support the increased desires of these students to pursue majors in STEM disciplines was also explored including effects of mentorship, supplemental activities outside of research, and group collaboration.

Introduction

Presently, percentages of groups typically underrepresented in the careers pertaining to science, technology, engineering, and mathematics (STEM) are not significantly improving. African Americans, Native Americans, and Hispanics make up 30% of the nation's undergraduates, however these groups are not choosing STEM careers at levels needed to significantly diversify these disciplines. Presently, less than one-quarter of the STEM Bachelor's degrees awarded are to any member of traditionally underrepresented group (NSF, 2017), and this rate is not growing. This has been linked to several factors, including 1) lack of interest in such fields; 2) lack of adequate preparation and skills needed to succeed in these areas; and 3) lack of encouragement to pursue careers in these fields (Clark et al., 2015). For many of these students, the lack of exposure to these types of careers and possibilities has essentially robbed them of their ability to even consider such careers. Experts monitoring the fields of science and engineering have determined that if the relative participation rates of these traditionally underrepresented groups does not increase, the overall STEM fraction of the total U.S. workforce may decline (Chubin et al., 2005; Zimmerman and Vanegas, 2007). To help address these concerns, the Program of Excellence for Science, Technology, Engineering, and Mathematics (PE-STEM) was developed and instituted at Florida Agricultural & Mechanical University (FAMU). The PE-STEM Program seeks to increase the participation of underrepresented ethnic minorities, particularly women, in science and technological careers by increasing the African American involvement in STEM disciplines. One of the major thrusts of this program was to expose high school students from these groups to research in various STEM-based disciplines.

Background

It has been reported that identities and attitudes toward STEM are more fully formed by the high school years. Many high school programs place more focus on increasing students' STEM knowledge base and test scores in gateway courses that serve as precursors to undergraduate STEM courses (Atwater et al., 1999; McShea and Yarnevich, 1999; and Valla and Williams, 2012). However, it has long been recognized that experiential, hands-on education provides superior motivation for learning new material, by providing real-world meaning to the otherwise abstract knowledge (Mataric et al., 2007). This hands-on exposure of traditionally underrepresented students would be facilitated through the PE-STEM Program.

Program of Excellence in STEM (PE-STEM)

The overall goal of the PE-STEM program is to increase the number of students from groups traditionally underrepresented in STEM disciplines, with the ultimate goal being graduating with a bachelor's degree (or higher) and employment in a STEM profession. This process was initialized at the high school level, used a 3-tiered approach focusing on recruitment, retention, and graduation. The involvement in applied research connects the three tiers in that having the opportunity to participate with actual research faculty is used to *recruit* students to the program; the mentorship of the faculty to the students while they participate in interesting, innovative research keeps them *retained* in STEM disciplines; and the addition of the research experience to their portfolio supports their *graduation* and matriculation in STEM majors and future careers. The cornerstone of the PE-STEM program is the PE-STEM Summer Academy held on the campus of FAMU. A major component of this summer program is the participation of the high school student participants in research with mentorship relative to STEM fields. Each PE-STEM Scholar chose one of three STEM-related discipline tracks: Science, for students interested in physics, biology, chemistry, or environmental sciences; Technology/Mathematics, for students with interest in computer science, mathematics, or technology majors; and Engineering, for all students with interest in various engineering disciplines. Scholars spent a half-day on research-related activities guided by STEM faculty on innovative topics, generally of great interest to students. Presently, the program is in its 6^{th} and final year, but has hopes of garnering more funding.

STEM Exposure through Program

A major benefit of the PE-STEM Academy is the research aspect that allows for students to get more "hands on" learning with mentoring while working on real STEM projects relative to their fields of interest. Literature has shown that the involvement of this pre-collegiate populations in interactive STEM activities has a highly significant role in students' selection and graduation from these disciplines, especially minority students (Cleaves, 2005). Syed et al. (2012) stated that summer programs can provide ethnically diverse adolescents with mentoring opportunities not previously available to them, and that a supportive environment such as these opportunities can greatly encourage students to become more involved in STEM and ultimately pursue a STEM-related career. This opportunity to interact with experienced STEM researchers

and students who are invested in their success will inspire and encourage students to strive for greater heights in STEM fields. As all of the PIs and faculty mentors belong to groups that are traditionally underrepresented in STEM fields, it has been noted that mentors with similar backgrounds as their students, especially adolescents, allow students to draw inspiration in visualizing their future (Oyserman et al., 1995), which is a positive aspect of the PE-STEM Program at an HBCU (Fries-Britt et al., 2012), such as FAMU.

It is often difficult for underrepresented students to become involved in STEM research due to the challenges they face in the courses that constitute these disciplines. Students often have difficulty in early collegiate STEM foundational courses because they fail to see their relevance to the applied work they seek in the future. Their exposure to research-related activities guided by graduate and undergraduate students, as well as STEM faculty, often seems to help with the ability of participants to be motivated and succeed in these courses (Clark et al., 2018). The program also improves the exposure of the participants to STEM research by providing an introduction and practice with material generally seen in the first two years of STEM majors in college. This growing familiarity with STEM material has been found to greatly increase student retention and success in the foundation courses which would lead to success in later applied coursework within STEM disciplines. This exposure can also demystify the coursework and prepare young people, especially those of underrepresented groups, who have built up in their minds a barrier towards STEM disciplines. This clarification can facilitate interest and reduce anxiety of the students towards STEM foundation courses and may encourage them to seek to enroll in courses in high school, which can lead to success in later applied coursework within STEM, as the literature has stated (Tai et al., 2006; Maltese and Tai, 2010). The by-product of this improved attitude towards science and math in high school will be validated by increased success and retention in these subjects through high school, college, and further to careers in STEM.

Results and Discussion

The PE-STEM Program measured how its implementation effected its participants on their decisions toward selecting a STEM major in college and a career in STEM subsequent to their graduation. One of the major aspects of the program was to expose these traditionally underrepresented students to STEM disciplines through research experiences and mentoring.

The survey data were directly related to the PE-STEM Scholars' thoughts before and after participation in the program.

Overall Program Evaluation

Based on survey of PE-STEM Scholars, a vast majority, ***~95%***, believed that the program was effective in encouraging its participants to pursue a college degree in a STEM area (see Figure 1). As the PE-STEM program is in its fifth year, evaluation of past participants has supported the fact that many of the Scholars did indeed choose to major in STEM in college, and that their hands-on research experience within PE-STEM helped inform their selection (Clark et al., 2015; Ardley et al., 2018; Clark et al., 2018).

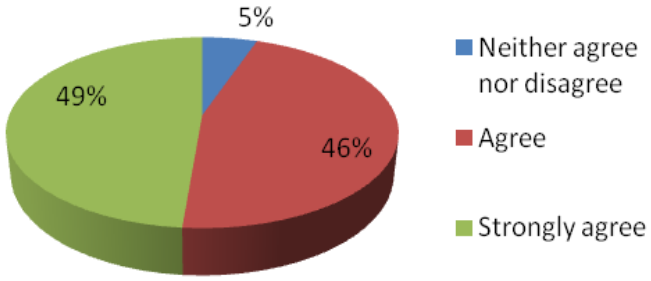

Figure 1. PE-STEM effectiveness in encouraging participants to pursue degrees in STEM areas.

It was also found that reported that after completion of the program, over 90% of PE-STEM participants have chosen to major in a STEM field in college. This was an ***increase*** of nearly 20% compared to those who thought they would pursue a STEM major when surveyed before they participated in the program. The exposure to hands-on, STEM-based research projects not only allowed inspired increased number of to students to decide a STEM major in college, but it was also helpful in helping select the specific field in which to major. Data showed that **~91%** of the students felt the PE-STEM program helped its participants understand and select their particular STEM-based major in college (see Figure 2).

Further results showed that those participants that would actually seek a career path in STEM also **increased** from around 70% to up ***over 92%***. It was interesting that the percentage of students choosing a career path in STEM was not the same, and even greater than those who would select STEM as a major in college. The difference in these percentages could be

attributed to the success of the program allowing students to see the lifetime importance of STEM, even if they don't see the collegiate discipline that initially interests them.

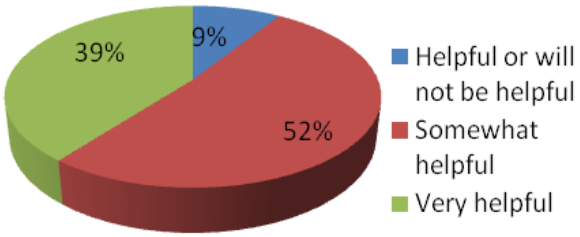

Figure 2. PE-STEM effectiveness in helping participants to choose a specific major.

It was also clear that one of the major reasons that PE-STEM was successful in helping the Scholars was that they enjoyed the research mentorship and experiences provided by the program. Of the greater than 70 participants, **95%** stated that they would recommend PE-STEM to their peers. Furthermore, ***all*** of the participants stated that they would choose to return to the program.

Importance of Exposure to Applied Research

The PE-STEM Scholars were surveyed on how the exposure to research specifically affected their attitudes toward STEM, especially with regards to their potential future within those disciplines. There is great significance in this knowledge, as hands-on research experience has been listed as one of the major factors in encouraging students, especially minority students, to seek future involvement in STEM majors and careers (Mataric et al., 2007; Black et al., 2015; Christensen et al., 2015). With regards to the research experiences, ***all 100%*** of the PE-STEM Scholars stated that the research internships provided for them by the PE-STEM Program were greatly influenced their motivation to be involved with STEM in their future (Figure 3). Of this total, **~94%** strongly agreed that the research exposure was significant in helping those who choose to become involved in STEM.

The participation in innovative research allowed for the Scholars to see their ability to succeed in important work that is of actual significance to solving real-world problems. In addition to the research itself, the mentoring in the experiences provided the Scholars the chance to participate, and even fail in some instances, with various STEM based research projects. In having the ability to learn from successes and failures, the program empowered students to think

of themselves as STEM practitioners. The program's importance was also underlined in the fact that for **92%** of the students, **PE-STEM provided them with their first actual research experience**. Without the program, these students would not have the exposure to STEM fields that would inform their choices to pursue them in college and as careers.

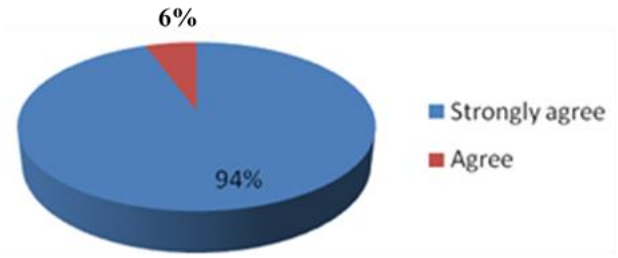

Figure 3. Scholars' evaluation on the significance of PE-STEM research experience.

Overwhelmingly, students indicated that the hands-on research experience (Figure 4) with the involvement of the faculty and student mentors were pivotal in the changes in their attitudes toward the STEM disciplines, as was also stated in an earlier version of this program (Clark et al., 2015). In addition, the PE-STEM program also compared favorably with other STEM programs that instituted similar interventions, especially hands-on research experiences, targeting minority students (Clark et al., 2018).

Figure 4. PE-STEM Scholars participating in laboratory research

Conclusions

The PE-STEM program at FAMU was developed and implemented to expose students from traditionally underrepresented groups to pursue degrees and careers in STEM by providing both hands-on research opportunities and mentorship. Surveys evaluating the program's effectiveness were conducted based on the attitudes of the participants. Results reported that respondents believed that the PE-STEM program provided them valuable research experience on interesting and significant STEM based projects. PE-STEM was noted to increase the percentage of participants who desired a career in a STEM field nearly 20%. Moreover, after participation in PE-STEM, the percentage who sought to major in STEM disciplines in college also increased nearly 20%. These positive trends in students' attitudes towards STEM showed the effectiveness of the PE-STEM Program, especially as 95% would recommend the program to their peers. Overall, **all** of the PE-STEM participants would seek to return felt that their participation and exposure to STEM-based research projects, under the mentorship of university faculty, was a major factor in their increased encouragement to pursue STEM majors and careers.

Acknowledgements

The authors wish to thank the Minority Science and Engineering Improvement Program (MSEIP) of the U.S. Department of Education for the funding of this project and Florida A&M University for its support in the implementation of this grant. The authors wish to most thank God through their Lord and Savior guidance and the prospering of the project.

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