AC 2010-2029: ENHANCEMENT OF LEARNING OUTCOME AND RETENTION OF MINORITY STUDENTS IN ENGINEERING

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Enhancement of Learning Outcome and Retention of Minority Students in Engineering

Abstract

The participation of African American Engineers in the national workforce is extremely low, which is a real concern and needs immediate attention to improve diversity. This paper first addresses the various causes of this low representation, and then discusses some remedies.

Based on a survey conducted, involvement of undergraduate students in research or projects related to their discipline, financial assistance and proper mentoring were found to be among the top factors that can improve the learning outcome and retention of underrepresented minority students in engineering.

A group of ten undergraduate engineering students were engaged in a challenging project to develop a high power Rocketry Program at Alabama A&M University in cooperation with NASA and Alabama Space Grant Consortium. The students were involved in the design, construction, testing, launching, and recovery of a reusable rocket with a science payload. The activities involved diverse aspects such as planning and scheduling, purchasing, performing calculations and analysis, coordinating logistics, and design reviews. They were mentored by faculty advisors. In addition, several minority students were engaged in undergraduate research utilizing cutting edge technology, which also provided them financial support. Another survey conducted shows that, these research/project experiences have brought excitement in their learning process, had a tremendous impact on their careers, motivated the minority students to become successful engineers, improved their learning outcome and self-confidence, prepared them to join the national engineering workforce and improve diversity, and even motivated some of them to pursue graduate studies. This paper shows that by introducing undergraduate research opportunities, financial support and proper mentoring, the enrollment, retention and successful graduation of underrepresented minority African American Engineers (male and female) can be significantly increased which will lead to a balanced workforce and improve the national economy.

1. Background

In an increasingly competitive and technology driven global economy, there is a growing concern regarding ability of the U.S. to remain competitive. The 2006 American Competitive Initiative (ACI) program emphasizes that education is the gateway to opportunity and the foundation of a knowledge-based, innovation driven economy, and when it is accompanied with training and retaining it will provide the nation's workforce with opportunities for advancement and the ability to compete in a global economy. However, gaps in race/ethnicity and gender at entry and in completion of science, technology and engineering programs indicate that the U.S. struggles to develop a diverse workforce that can compete globally. Alabama Agricultural and Mechanical University (AAMU) is a historically black (HBCU) land-grant and EPSCoR institution established in 1876 with a mission of providing high quality education for about 5500 underprivileged, mostly low-income African-American students. The university offers baccalaureate, masters and doctoral level degrees that are compatible with the times to all qualified and capable individuals who are interested in further developing their technical, scientific, professional, and scholastic skills and competencies. The ethnic distribution of students at AAMU is 92% black, 4% white, and 4% represented by all others. In the School of Engineering and Technology at AAMU, the distribution of students based on gender in Fall 2008 was 76% male and 24% female. In 2006, AAMU set a priority to provide low-income students with higher education and ensure their success through retention, graduation, and advancement.

Alabama A&M University, a center of excellence, provides an educational environment for the emergence of scholars, scientists, leaders, critical thinkers, and other contributors to a global society. AAMU is located in Huntsville, Alabama, which is known internationally as a center of aerospace and defense technology. Huntsville is considered as a leader in high-tech research, engineering services, information systems design and in the manufacturing of computing equipment, telecommunications, space vehicles and rocket propulsion, and attracts some of the greatest minds in the world. It is the home of more than 50 Fortune 500 companies. These industries and government agencies require a large number of qualified engineers.

Alabama A&M University's School of Engineering and Technology offers three engineering programs, Civil Engineering, Electrical Engineering and Mechanical Engineering, in addition to the Technology and Computer Science programs. The School of Engineering and Technology presently enroll about 840 students.

Civil Engineering (CE) includes the broad categories of construction, structural engineering, soil mechanics and foundations, transportation systems, water resources, hydraulic engineering, and environmental engineering. The Department of Civil Engineering at Alabama A&M University provides a general academic background while allowing a student to concentrate on a specialized area by selecting technical electives. The Department offers a major leading to the Bachelor of Science in Civil Engineering and provides basic courses in all of the areas: Structural Analysis and Design, Geotechnical Engineering, Environmental Engineering and Water Resources, and Transportation Engineering.

The Department of Electrical Engineering offers courses leading to the Degree of Bachelor's of Science in Electrical Engineering. Students are prepared to pursue careers in technical areas such as power systems, communications, signal processing, integrated circuits, computers, manufacturing, and robotic systems. Graduates pursue careers in manufacturing, research and development, and management. They are also prepared to pursue private practice and graduate education.

The Mechanical Engineering (ME) program at Alabama A&M University encompasses the traditional roles of Mechanical Engineering in areas of analysis, design, manufacturing, and testing of mechanical and thermal systems, while also including system integration, propulsion systems, concurrent engineering, and other competitive manufacturing practices, leading to the Bachelor of Science Degree in Mechanical Engineering. Based on the local demand, the program has two options: Manufacturing and Propulsion. The Mechanical Engineering Department at AAMU is committed to prepare students in these options, to work efficiently for various industries and government.

The Mechanical, Electrical and Civil Engineering programs at AAMU were successfully accredited by the Accreditation Board for Engineering and Technology (ABET)[1], the last one in Fall 2007. They also meet the requirements of the Southeastern Association of Colleges and Schools (SACS).

2. Causes of Low Enrollment of African American Students in Engineering

Developed countries like the United States need large engineering workforce. Even in Huntsville, the city where Alabama A&M University is located, it is anticipated that about 15000 new engineers will be needed over the next ten years[2]. But unfortunately, the percentage of minority black engineers is very low compared to the percentage of their population[3,4].

To understand the reasons of poor representation of African American students in engineering, the first step was to explore the probable causes. Hence, a survey tool was developed with possible causes for low enrollment of minority students in engineering, particularly minority black students, and shown in Table 1. The survey tool was circulated among the minority students of Mechanical, Electrical and Civil Engineering departments of AAMU. The students were asked to rate their responses on a scale of 1 – 4. The student responses were compiled, averaged and presented in Fig. 1. In this figure, the horizontal axis denotes the item number for various causes as described in Table 1, and the vertical axis denotes the average rating for that particular item.

Table 1. Survey Tool for possible causes of low Enrollment of African American students in Engineering.

Civil / Electrical / Mechanical Engineering Department, AAMU

Survey Tool for causes of low Enrollment of African American Students in Engineering

In a scale of 1 to 4 (1 – minimum, 4 – maximum), rate the following items you believe might be possible causes for low enrollment of African American students in engineering:

Item #	Probable Reasons	Not Agree (1)	Somewhat Agree (2)	Agree (3)	Strongly Agree (4)
1	Lack of Motivation for challenging position				
2	Lack of proper Math and Science courses in High School				
3	Ignorance of engineering job prospect				
4	Lack of exposure to engineering work-environment and job pattern				
5	Ignorance of engineering job salary compared to other jobs				
6	Fear of Math				
7	African American students have a general tendency to study Liberal Arts / Humanities subjects				
8	Lack of motivation or influence from Family to study engineering				
9	Economic condition / Financial hardship				

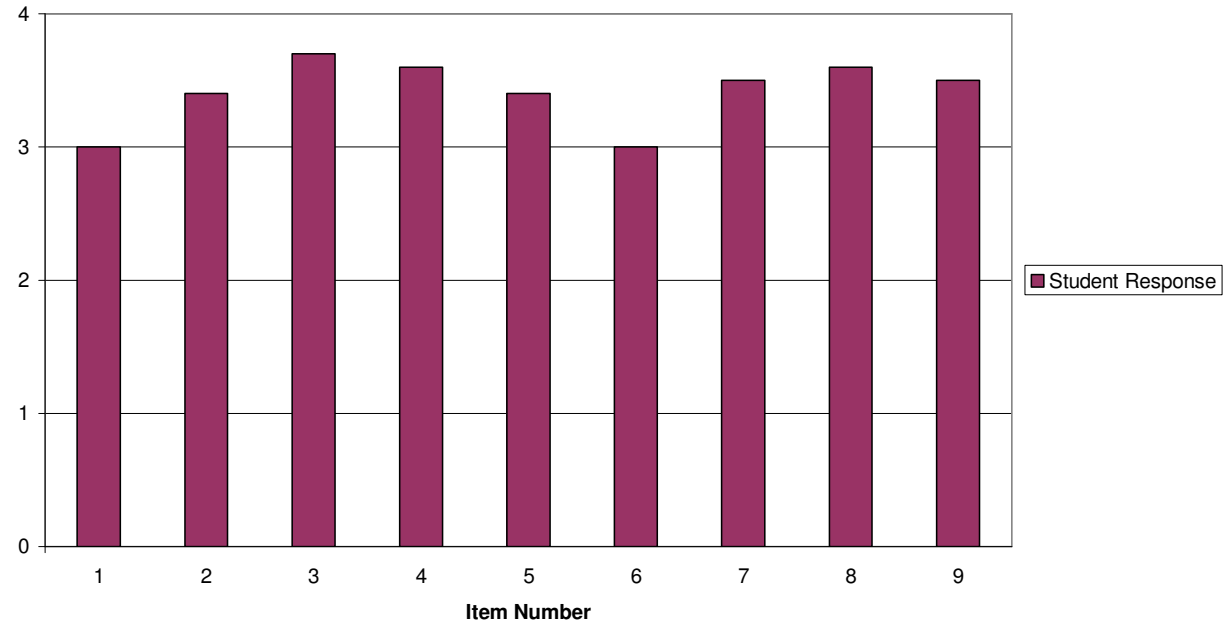

Fig. 1. Response of students about the items that might be possible causes for low enrollment of African Americans in engineering.

From Fig. 1, it is observed that almost all of the students strongly agree that minority African Americans are ignorant about engineering job prospect. In addition, most of the students agree that lack of proper Math and Science courses in high school, lack of motivation or influence from family to study engineering, general tendency to study Liberal Arts or Humanities subjects, lack of exposure to engineering work-environment and job pattern, and economic condition are some of the major factors that affect the enrollment of minority students in engineering.

To meet their financial needs such as tuition, book fees and lodging, approximately 90% of the minority students enrolled in different engineering programs spend more time working different low-pay jobs instead of attending university. This leaves them tired and inattentive in class and they often show up late or not at all. Subsequently, this affects their grades and ultimately they are not interested in continuing their studies. But students who received financial support had a substantially higher retention rate and grades.

3. Solutions to Increase Underrepresented Students in Engineering

For finding the probable solution to increase enrollment and retention of African American students in engineering a survey tool was also developed with some suggestions or ideas, and presented in Table 2. The survey was again conducted among the minority students of the Civil, Electrical and Mechanical Engineering departments of AAMU. The survey results were processed and presented in Fig. 2. In this figure, the horizontal axis denotes the item number for various probable solutions as described in Table 2, and the vertical axis denotes the average rating for that particular item.

In Fig. 2, it is found that the students strongly agree that more scholarships for freshmen and sophomore students, more summer internship opportunities for minority students, involvement of undergraduate students in research or projects related to their engineering discipline, and providing adequate academic mentoring to the undergraduate students are needed to increase the enrollment and retention of African American students in engineering. In addition, giving proper idea about engineering work environment and job pattern, and increasing awareness about job prospect and benefit for engineering jobs among high school students would help to increase the enrollment of minority students in engineering.

Table 2. Survey Tool for possible solutions to increase minority students in Engineering.

Civil / Electrical / Mechanical Engineering Department, AAMU

Survey Tool to increase Enrollment and Retention of African American students in Engineering

In a scale of 1 to 4 (1 – minimum, 4 – maximum), rate the following items that you believe might help to increase the enrollment and retention of African American students in engineering:

Item #	Suggestions / Ideas	Not Agree (1)	Somewhat Agree (2)	Agree (3)	Strongly Agree (4)
1	More scholarships for freshmen and sophomore minority students				
2	Encourage minority students at high school to take math and science courses to prepare for engineering				
3	Increase awareness about job prospect and benefit for engineering jobs, among high school students				
4	Involve undergraduate students in research or projects related to their engineering discipline				
5	Provide adequate academic mentoring to the undergraduate students, faculty and peer monitoring				
6	Arrange supplemental math and science courses for freshmen students				
7	Give proper idea about engineering work environment and job pattern				
8	More Summer Internship opportunities for minority students				

9	Communicate with families to encourage students to study engineering for better prospect				

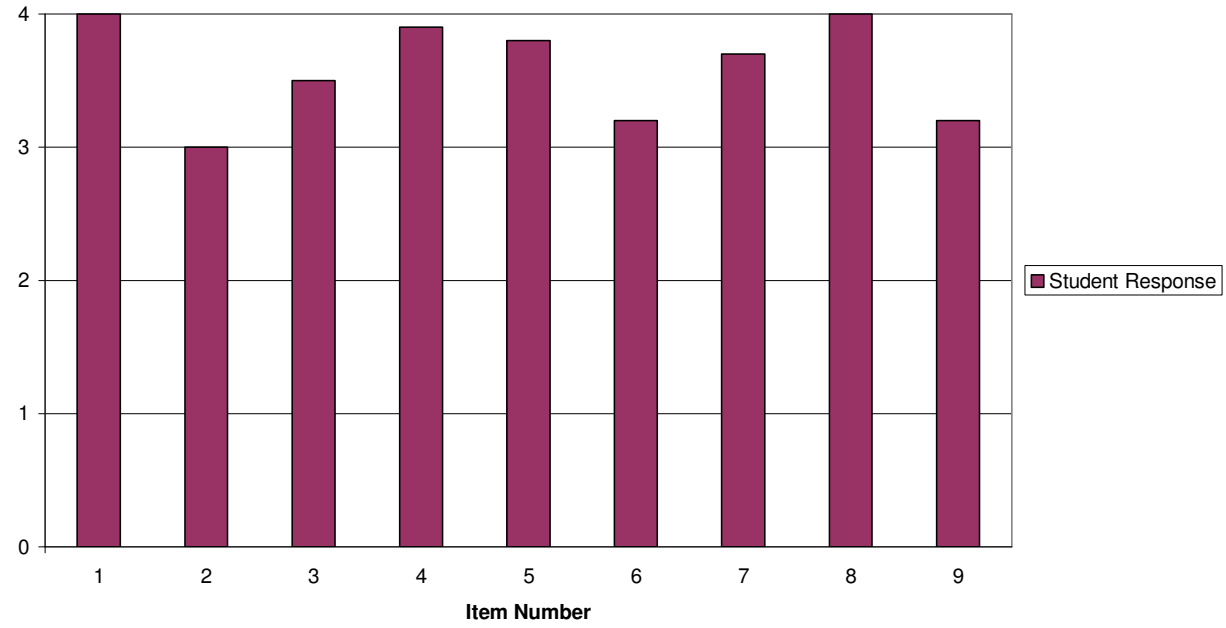

Fig. 2. Response of students about the items that might increase enrollment of African Americans in engineering.

4. Study on a Cohort of Students for Enhancement of Learning Outcome and Retention

A group of ten undergraduate engineering students from the mechanical, electrical and civil engineering departments were engaged in a challenging project to develop a high power Rocketry Program at Alabama A&M University in cooperation with NASA and Alabama Space Grant Consortium. The students were involved in the design, construction, testing, launching, and recovery of a reusable rocket with a science payload. The activities involved diverse aspects such as planning and scheduling, purchasing, performing calculations and analysis, coordinating logistics, and design reviews. They were mentored by two faculty advisors from the mechanical engineering department. In addition, three minority mechanical engineering students were engaged in undergraduate research utilizing cutting edge technology on nanocomposites, which also provided them financial support. A survey was conducted among this cohort of students involved in research or projects. The survey tool developed with possible suggestions or ideas to enhance the learning outcome and retention of African American students in engineering is presented in Table 3. Responses to the survey were processed and presented in Fig. 3. In this figure, the horizontal axis denotes the item number for various suggestions as described in Table 3, and the vertical axis denotes the average rating for that particular item.

The survey shows that, these research/project experiences have brought excitement in the students' learning process, had a tremendous impact on their careers, motivated the minority students to become successful engineers, improved their learning outcome and self-confidence, prepared them to join the national engineering workforce and improve diversity, and even motivated some of them to pursue graduate studies.

Table 3. Survey Tool to assess the enhancement of Learning Outcome and Retention of minority students in Engineering due to undergraduate research/project.

Civil / Electrical / Mechanical Engineering Department, AAMU

Survey Tool to assess the enhancement of Learning Outcome and Retention of African American students in Engineering

In a scale of 1 to 4 (1 – minimum, 4 – maximum), rate the following items that you believe might help to enhance the Learning Outcome and Retention of African American students in engineering:

Item #	Suggestions / Ideas	Not Agree (1)	Somewhat Agree (2)	Agree (3)	Strongly Agree (4)
1	Financial Assistance for the undergraduate minority students				
2	Involvement of undergraduate students in engineering research or projects related to their discipline				
3	Involvement in research/project brought excitement in the learning process				
4	Involvement in research/project motivated the student to become successful engineer				
5	Involvement in research/project improved student's learning outcome and self-confidence				
6	Involvement in research/project prepared the minority students to join the national engineering workforce and improve diversity				
7	Involvement in research/project motivated the students to pursue graduate studies				
8	Provide adequate academic mentoring to the undergraduate students				

9	Give proper idea about engineering work environment and job pattern				
10	More Summer Internship opportunities for minority students				

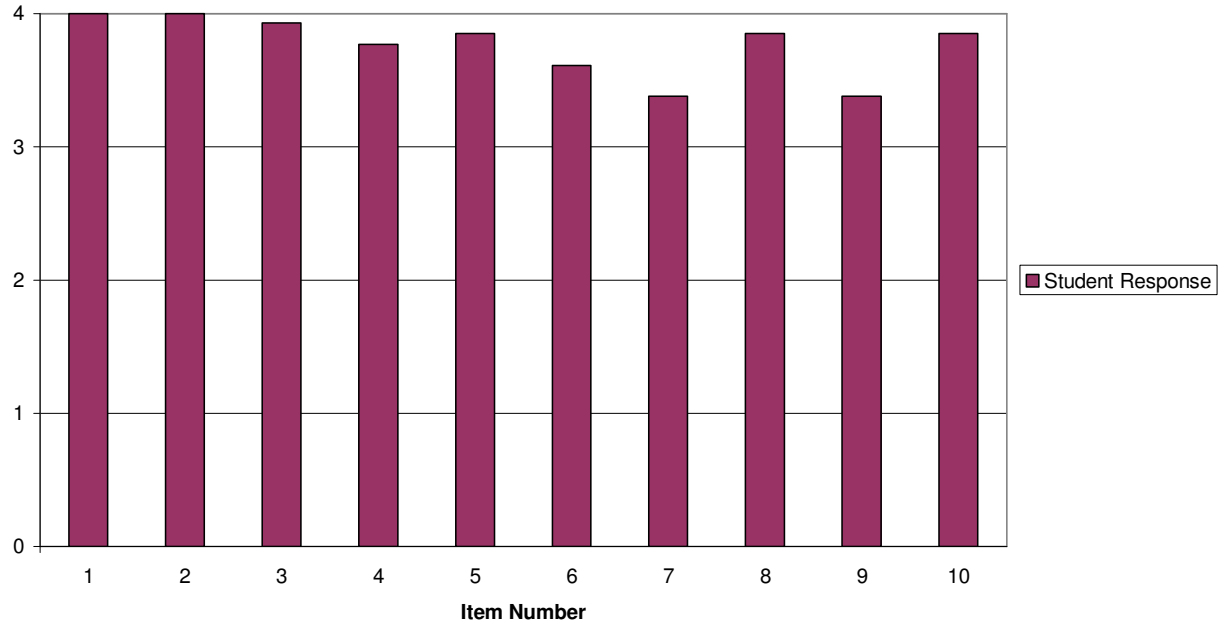

Fig. 3. Response of students about the items that might enhance the Learning Outcome and Retention of African American students in engineering.

5. Conclusion

This paper shows that by introducing undergraduate research opportunities, financial support and proper mentoring, the enrollment, retention and successful graduation of underrepresented minority African American Engineers (male and female) can be significantly increased which will lead to a balanced workforce and improve the national economy.

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