Identification of Factors Affecting the Retention of Underrepresented Minorities in Engineering

Sidney E. Martin, III PE and Ben Littlepage, Ed. D.
Murray State University/Murray State University

Abstract

In 2050, there will be no clear racial majority in the United States. Recently, the rate of births to underrepresented minorities has exceeded the rate of births for whites. In engineering, women are considered an underrepresented minority and include African Americans, Hispanics, Native Americans and Pacific Islanders, and disabled individuals[1]. Engineering departments in academia must adapt to the learning needs of these underrepresented minorities which will aid students' success in the classroom. Engineering faculty have been researching the implementation of active learning pedagogy for nearly 40 years. Engineering faculty need to utilize teaching styles congruent with the learning styles of engineering students. Other integration activities such as peer mentoring, peer advising, and participation in professional associations reflective of one's identity have shown gains in retaining underrepresented minority students. The preliminary research presented in this paper will be based on a qualitative case study, grounded theory design. The study explores what pedagogical and integration strategies universities are utilizing to graduate a proportionally high number of underrepresented minorities. The participating universities annually award a high number of degrees to underrepresented minorities relative to other universities with engineering programs. Administrators and faculty were interviewed to determine what activities were important to the retaining of underrepresented minorities. Preliminary implications for practice and future research suggestions will be shared in the paper.

Keywords

Retention, active learning, underrepresented, minorities

Introduction

This research is a grounded qualitative case study that is in progress with an expected completion date of May 2018. The goal of this research is to identify the factors which could positively aid in the retention of underrepresented minorities pursuing a degree in engineering. Factors may include practices associated with instruction, mentoring, advising and other methods to be revealed by the grounded study design. In this study, retention is considered to be the freshmen to sophomore retention rate in engineering. The freshmen to sophomore retention rate measures the percentage of full time, first time engineering students enrolled at the university the following fall semester still in engineering. Underrepresented minorities for this study

In a traditional engineering classroom, students are encouraged to reproduce their memorized knowledge on exams to demonstrate their comprehension of the presented materials. Engineering students are encouraged to work together. Cooperation between students in some classrooms is restricted among the students resulting in inability share their knowledge with each other and the faculty member[2]. Engineering professors need awareness of other learning and teaching styles to utilize skills such as cooperation, team, and problem-based learning which are skills that industry seeks in new hires.

Engineering innovation, the primary ingredient to corporate survival and competitiveness for industrial organizations, is the byproduct of a diverse workplace. Progressive companies, organizations, and institutions are actively working to find opportunities to build inclusive product development and research teams to take advantage of the relationship between innovation and diversity.[3] Munson and Gallimore[4] report that companies with diverse workforces outperform and out-innovate their competitors. Companies composed of diverse employee teams increase innovation by 45% and report increased market share gain, and 70% of companies report that they have moved into new markets.[5] Technology businesses that employ high numbers of engineers are finding that increased diversity in the organization contributes to global competitiveness, greater product innovation and achieving successful business outcomes[6]. Page points out in his book that innovation and progress are less dependent on the individual thinker with high intelligence and more dependent on diverse teams of people cooperatively working with each other and taking advantage of each member's individuality. Page indicates that diversity is not only what the individual looks like on the outside, but what the individual ethos, or character, is on the inside.

A team making decisions and predictions will result in improved engineering performance through drawing on the unique qualities of the group's members. Team members can relate to each other based on functions while utilizing the performance benefits diversity brings. Diversity increases the opportunity for the quality of work and creativity of the group work final product.[7,8]

Literature Review

A need exists to address teaching techniques used by professors and instructors in engineering[8]. The traditional approach of standing in the front of the class teaching from the textbook may cause students to become uncomfortable with their decision to study engineering[9]. Interesting lecturers can enrich the classroom process, but these students will learn whether they have an enjoyable and enriching experience or not. In the U.S., the intention of engineering departments is to educate a broad swath of the population. Engineering students cannot readily complete engineering classes with the support that the traditional teaching schemes provide as not all learning styles are utilized. Felder and Brent[9] state that the goal is not to move from traditional teaching to cooperative or active based or problem-based learning in a short period. Rather, the movement to active based learning is done by adding active learning practices slowly to the established course. Felder[10] indicates the traditional teaching approach contributes to the high attrition seen routinely in engineering. The traditional paradigm of lecture, homework, and testing can be ineffective, and without additional methods of engagement, the underrepresented minorities will struggle to succeed in this environment. Felder[10] recommends that instructors should try new arrangements of teaching in their classrooms.

Mastascusa, Snyder, and Hoyt[11] outline that faculty should not lecture the entire period. The continuous discourse will overload the short-term memory, and there will be no time to process the information presented. When the amount of lecture has filled the short-term memory, a pause in passive instruction should occur. Mastascusa et al. report a break period is needed after filling the short-term memory and is the time to insert a short active learning experience. During these break periods, the students are mentally processing the recently introduced material. Matascusa et al. report that collaborative activity will help students store the material in the long-term memory. There is no need for the engineering students to worry about content during the activity; the collaborative activity allows students to have a better opportunity to develop long-term retention of the material. The students understanding of the material should be checked with a short exercise to ensure comprehension. At the end of the lecture, a short reflective period should be given, or a summary activity such as writing a one-minute paper.[11] Reflective periods allow the engineering student sufficient time to absorb the material presented by the instructor.

Changing the engineering instruction, through the use of nontraditional styles of instruction, will result having the students challenged-to question their own ideas and others.[12] Standing in the front of the classroom and talking to the student may not be helpful to develop the low-performing student (2.0 to 2.4 GPA) who may exit engineering as a field of study instead of completing the engineering degree.[13] The transition of engineering instruction will be difficult as historically engineering professors have not mollycoddled engineering students. The Society for the Promotion of Engineering Education[14] and Survey of Rutgers University Engineering[15] historically illustrate the tendency to coddle the engineering student is a serious error in engineering university instruction.

Engineering educators are working in the classroom to develop engineers who understand their field of study well, though there are no specific approved pedagogies for engineering.[17] By approaching education with the concepts of memorization and repetition techniques, this emphasis fails to train emerging engineers to solve societal problems today. [11] Engineering instructors need to be encouraged to teach the mechanics, not formulaic process, of how to reason through problems. Engineering instructors need to step beyond the routine use of simple problem solution and memorization to a point where the professors do not routinely ask students to analyze a situation. Although engineering professors should encourage a student to express independence of thought and creativity, too often the professor does not reward or encourage student expressing independent thoughts.

Learning Styles

Felder[16] indicates that all students do not learn in the same way, and they do not respond well to the same teaching styles. Those engineering students with different learning styles will have different strengths. Catering instruction towards one set of learning preferences or needs may eliminate the students who would also make good engineers. Instruction should be balanced utilizing an alternation between learning styles. Felder reports distributing the method of teaching using various learning styles will contribute to retaining students in engineering.

Felder and Silverman[18] reported that there could be a mismatch between traditional and shared learning styles of engineering students versus the traditional styles of teaching employed by engineering professors. Felder[18-20] has grouped engineering students into one of the four learning styles described below:

- Sensing learners (practical, concrete, oriented toward procedures and facts) or intuitive learners (innovative, conceptual, geared toward meanings and theories);
- Visual learners (prefer visuals to represent material – flow charts, pictures, plots, animation, diagrams) or verbal learners(prefer spoken or written instructions and explanations);
- Active learners (learn by working with others, by trying things out) or reflective learners (learn by working alone, by thinking things through);
- Sequential learners (orderly, linear, learn in small incremental steps) or global learners (systems thinkers, learn in large leaps, holistic).

Methodology

The researchers will review accessible public data regarding universities that service the underrepresented minority students in engineering programs. The researchers identified 45 engineering schools that graduate women, African Americans, and Hispanics at a higher rate than other institutions. Access to the American Society for Engineering Education (ASEE) was used to obtain demographic information regarding participating institutions and the graduation rates of URM. Independent data sources were also used to confirm the ASEE information. Confirming data was obtained from university websites and published reports. The ranking of the universities within the list of 45 was established by combining the number of diplomas to African Americans and Hispanics and calculating the percentage of diplomas granted to these two groups.

The researchers conducted in-person interviews with deans, chairpersons, appropriate faculty and graduates who are knowledgeable of teaching and active learning at these institutions except in those instances noted where a group of individuals was organized to the convenience of the participants. Faculty were contacted who are members of American Society for Engineering Education and may have published articles regarding engineering education and active learning. This extended the researchers' knowledge of the programs and teaching methods that successfully help the URM. Forty-five institutions were selected based on the number of underrepresented minorities receiving a degree with other factors such as reported retention used to establish a ranking. The authors remained open to discussion with any institutional member who expresses interest in discussing the retention of URM which is associated with one of the top 45 identified universities.

The researchers will review the data looking for the common themes in the data and bucket the information. Yin[21] suggests five manners of analyzing the data. The anticipated process used to analyze the data will be pattern matching and explanation building. The researchers' role is critical as the interviewer and is key to the interpretation of the lived experiences. In a grounded design, Lawrence and Tar[22] report that the goal of grounded theory is to find a theory or theories that are closely tied to the evidence and is consistent with empirical data. The data collection, techniques of coding and grouping, development of categories and gathering information from the data and the development of theories is guided by the emerging development of themes. The study's research goal is to develop theories that relate to the positive and negative retention of URMs in engineering. The theory is grounded when the theory emerges and explains events and relationships within the life experiences those processes and people that the researchers are working to understand. By analyzing the data from the lived experience of the research participants, the researchers can begin to understand how the study participants construct their worldview. An issue with the grounded theory is that the method is labor intensive both in obtaining and transcribing the in-person interviews.

The researchers engaged the participants in introductory comments. The recorded interviews were transcribed with a code reference to the individual. The transcription was sent to the participant for verification of correctness.

Results

The comments around active learning varied. Most faculty talked about using active learning as their teaching style. One comment that stood out stated that active learning makes class more interesting. ”Who wouldn’t want to stick around for interesting classes? However, just because active learning is supposed to help retention of students, this doesn’t mean that it’s true that active learning helps to retain underrepresented minorities. Media and proper selling convinced people that they wanted to smoke cigarettes despite the health issues which were hidden or not displayed. So, is active learning better? One of the faculty members interviewed reported ’We think active learning is more interesting and that it engages students. However, that doesn’t mean active learning is a better pedagogy.” Our research at 14 engineering institutions successfully graduating underrepresented minorities indicates that 10-25% percent of faculty are using active learning in some aspect in some classrooms.

Common themes indicate activities beyond pedagogy contribute to the retention of underrepresented minority students. The consistent utilization of these activities was seen as beneficial to the purpose of this study. The student’s involvement in undergraduate research the student is brought into a faculty member’s team and introduced to research, possibly to graduate students. The dorm and residence hall experience can be improved by having engineering students living in one dorm or a group of minority students placed into a dorm wing. A key action is to not put an engineer with a roommate who does not have to take calculus. Engineering student organizations are good to get students involved, this involvement in the organization’s projects and leadership help to improve retention of students.

Underrepresented students thrive when they can identify their own community. A place where they can develop a sense of identity (I can, I have, I remember, etc.). Whether this community location is a living area, an inclusive study area, or a location where the student feels like they belong. It is important that faculty consider being open. Faculty and staff should consider wearing shorts, or not wearing a tie and exhibit a demeanor that does not exclude and show interest in all students. For underrepresented students, there is importance in students seeing other students and faculty that look like them. And, if the student cannot see faculty who look like them then there’s importance in faculty caring about the way the student’s feelings. Faculty that care about students and the student success are helpful to the retention of all student success. A faculty member caring about the student can keep them in the program. The faculty needs to have an open door policy, when the student comes in the office, the faculty member stops and deals with any issue the student is experiencing. Or, if the faculty member cannot help at that specific moment the faculty member schedule an appointment to show that they care about talking to the individual.

Discussion

Retention was not found to be measured consistently from state to state, or institution to institution. A clear definition of retention and retention cohorts should be determined and agreed upon by organizations representing the various educational institutions in the US. This would aid in the comparison of universities and their programs.

Retention comprises many improvement strategies that faculty and academic affairs personnel can implement. Retention research finds that retention of students is the byproduct of 1.) sense of community, 2.) faculty interaction / mentorship, and 3) the use of active learning, regardless of student type and academic discipline[23]. Faculty and staff can have a significant influence on the students by providing interest in the student's well-being, involving them in their research and being friendly.

The goal should be to retain a student at the university. If the student stays in engineering and changes to another branch of engineering, this will be helpful in the retention measurement. Students lost from one branch of engineering during their four or six-year period may not be retained in their program, but they will remain within the engineering field which is a benefit to society.

Conclusion

The research work is continuing to identify those aspects that aid in the retention of URM. Active learning has been found to be a part of the methods that can be used by faculty to aid academic affairs in improving the retention of URMs. Methods that engage the student and have the student participate in learning are successful in improving the retention of the student as reported by those faculty members who were interviewed.

References

1 National Science Foundation (2016). Women, minorities, and persons with disabilities in science and engineering. As retrieved https://www.nsf.gov/statistics/2017/nsf17310/data.cfm

2 dos Santos, Simone, "PBL-SEE: An authentic assessment model for PBL-Based software engineering education." IEEE Transactions on Education, IEEE, Piscataway, NJ, 2017, 120-126.

3 Varrasi, John, Engineers: Diversity = innovation. *The American Society of Mechanical Engineers.* ASME Public Information, 2012. As retrieved https://www.asme.org/engineering-topics/articles/diversity/new-formula-for-engineers-diversity-innovation

4 Munson, David, & Alec Gallimore, Diversity, equity and inclusion strategic plan five-year strategic objectives, measures and FY 17 actions, 2016. *Michigan Engineering, University of Michigan.* As retrieved https://www.engin.umich.edu/wp-content/uploads/2017/08/CoE_DEI_StrategicPlan.pdf

5 Hewlett, Sylvia, Melinda Marshall, & Laura Sherbin. How diversity can drive innovation. *Harvard Business Review*, 2013. As retrieved https://hbr.org/2013/12/how-diversity-can-drive-innovation

6 Page, Scott, *The difference: How the power of diversity creates better groups, firms, schools, and societies.* Princeton, NJ: Princeton University Press, 2007.

7 DiTomaso, Nancy, Corrine Post, Rochelle Parks-Yancy. Workforce diversity and inequality, power, status, and numbers. *Annual Review of Sociology 33*, 473-501, 2007. DOI: 10.1146/annurev.soc.33.040406.131805

8 Daniel Williams, Morrill Act's contribution to engineering's education. *The Bent of Tau Beta Pi,* 15-20, 2009. As retrieved https://www.tbp.org/pubs/Features/Sp09Williams.pdf
9 Felder, Richard and Rebecca Brent, Teaching and learning STEM: A practical guide. Jossey-Bass, San Francisco, 2016.
10 Felder, Richard, "Teaching engineering in the 21st century with a 12th-century teaching model: How bright is that?", Chemical Engineering Education, Gainesville, FL, 2006, 110-113.
11 Mastascusa, Edward, William Snyder, and Brian Hoyt, Effective instruction for STEM disciplines: from learning theory to college teaching, Jossey-Bass, San Francisco, CA, 2011.
12 Felder, Richard, "Does engineering education have anything to do with either one? Toward a systems approach to training engineers", Engineering Education, London, England, Taylor & Francis Group, 1984, 95-126.
13 Davids, Lisa, James Pembridge, and Yosef Allam, "Video-Annotated Peer Review (VAPR): Considerations for development and implementation," *American Society for Engineering Education* 122nd ASEE Annual Conference and Exposition, Seattle, WA, 2015, 2-23.
14 Society for the Promotion of Engineering Education, Bulletin. The Society for Promotion of Engineering Education, 1917, Washington, DC, Society for the Promotion of Engineering Education.
15 Survey of Rutgers University Survey of Rutgers University: Engineering *Education.* Washington: Office of Education, 1927.
16 Felder, Richard. Engineering education: A tale of two paradigms. In McCabe, B., Pantazidou, M., & Phillips, D. (Eds.), Shaking the foundations of geoengineering education (9-14). Leiden, Holland, CRC Press, 2012.
17 Warnock, James, & M. Jean, Mohammadi-Aragh, Case study: Use of problem-based learning to develop student technical and professional skills. European Journal of Engineering Education, 2015, 142-153.
18 Felder, Richard, and Linda Silverman, "Learning and teaching styles: In engineering education," Engineering Education, London, England, Taylor & Francis Group, 1988, 674-681.
19 Felder, Richard, "Matter of style", Prism, Washington, DC, ASEE, 1996, 18-23.
20 Felder, Richard, "Learning and teaching styles in engineering education: Author's preface added", 2002, As retrieved http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/LS-1988.pdf
21 Yin, Robert. *Case Study Research.* Thousand Oaks: SAGE, 2009.
22 Lawrence, J., & Tar. U., The use of grounded theory technique as a practical tool for qualitative data collection and analysis. *The Electronic Journal of Business Research Methods, 11*(1), 29-40 (2013).
23 Litziler, E., & Samuelson, C., How underrepresented minority students derive a sense of belonging from engineering. *ASEE Annual Conference & Exposition,* Paper ID #6685, (2013).

Sidney E. Martin, III. PE, PMP

Mr. Martin has BSEE and MSEE from the University of Massachusetts at Dartmouth. Mr. Martin is ABD in the Ed.D. program at Murray State University. Mr. Martin is passionate about engineering education and is a registered professional engineer. Prior to joining Murray State University, he was director of operations for multiple organizations where he responsible for employee training and education in the manufacturing industry. Mr. Martin utilizes active learning techniques, which include problem-based-learning, story-based-learning, and other teaching styles.

Ben Littlepage, Ed.D.

Dr. Ben Littlepage is an Assistant Professor and Program Coordinator of the Master of Arts in Postsecondary Education Administration at Murray State University. Prior to becoming a faculty member, Dr. Littlepage was a higher education administrator for nine years at three different institutional types: state-assisted regional university, private liberal-arts college, and community and technical college. Functional areas for which he has administrative experience include academic advising, academic affairs, admissions and records, alumni relations, annual giving, career counseling, and first-year experience. His expertise lies in operationalizing and redefining functional units. His current research interest is organizational change imposed by Promise scholarship legislation. Ben Littlepage received his Ed.D. ('12) from the University of Memphis, and M.A.E. ('04) and B.S. ('02) from Western Kentucky University.