Improve Retention Rate and Recruitment of Minority Students through Enhanced Mentoring and Summer Research Programs

Dr. Hua Li, Texas A&M University, Kingsville

Dr. Hua Li, an Associate Professor in Mechanical and Industrial Engineering at Texas A&M University-Kingsville, is interested in sustainable manufacturing, renewable energy, sustainability assessment, and engineering education. Dr. Li has served as P.I. and Co-P.I. in different projects funded by NSF, DOEd, DHS, and HP, totaling more than 2.5 million dollars.

Dr. Mary L. Gonzalez, Texas A&M University, Kingsville

Associate Vice President for Student Access, Academic Affairs Oversite for $3.5 Million per fiscal year of federally and state funded resources for student access and success in Pre College and Collegiate aspirations. Possess 27 years of working in higher education and student development programs in STEM.

Prof. Mohamed Abdelrahman, Idaho State University

Dr. Abdelrahman is currently the Vice President for Academic Affairs and a Professor of Engineering at Arkansas Tech University. Dr. Abdelrahman has a diverse educational and research background. His research expertise is in the design of intelligent measurement systems, sensor fusion and control systems. He has been active in research with over 80 papers published in refereed journals and conferences. He has been the principal investigator on several major research projects on industrial applications of sensing and Control with focus on Energy Efficiency. He is a senior member of IEEE, ISA, and a member of ASEE.

Ms. Melinda Dynyel Miller
Prof. Kai Jin, Texas A&M University, Kingsville

Dr. Kai Jin is a Professor of Industrial Engineering and Co-PI of the MERIT project. Her research interests include Sustainable Energy, Green Manufacturing, Quality Control, and Multi Objective Decision Making and Optimization as well as Engineering Education. She has served as PI and Co-PI in several DoEd, DHS, NRC, and industry sponsored projects.

Dr. Maria Emilia Martinez, Texas A&M University, Kingsville

Dr. Martinez holds a Ph.D. in educational administration from New Mexico State University and her research interests include the examination of the lived experiences of underserved and underrepresented student and faculty populations in higher education. She employs quantitative methods as well as qualitative methods through case studies, narratives, survey instruments, and focus groups within ethnographic and phenomenological frameworks. Dr. Martinez currently serves as the Executive Director for Strategic Initiatives in the Office of Research and Graduate Studies at Texas A&M University Kingsville.

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1. Introduction

According to the report to the President in 2012 [1] and previous literature [2], less than 40% of the students who enter into STEM undergraduate curricula as freshman will actually graduate with a STEM degree. Only about 20% of STEM-interested underrepresented minority students finish with a STEM degree. The retention of STEM majors is a national problem. Nationwide, less than half the freshman who start in STEM majors graduate with a STEM degree, and at least half of this attrition occurs during the freshman and sophomore year. Clearly, the first two years are critical for both academic success and retention of STEM students [3]. STEM students begin their college education with a set of attitudes about STEM fields and their abilities to succeed. These initial attitudes and their changes during the freshman and sophomore year affect students' motivation, performance, and ultimately pursuing a STEM degree. There is strong evidence of success showing that attitudes are the most correlated with retention among all factors studied [4]. Research [5] shows the dropout rate of STEM students is much lower among upper level students as compared to those in the first two years. The more students reaching upper level status means the more students completing STEM degrees. Research also suggests that few students, even those who have had some prior exposure to engineering, know what engineers do, which affects their commitments to the engineering majors [6].

This paper presents the findings from a three-year transformative project (MERIT) funded by Department of Education focusing on engaging, mentoring, and retaining minority engineering students at Texas A&M University-Kingsville (TAMUK). The institutional needs at TAMUK were identified through a campus-wide approach involving various stakeholders and external consultants. Recognized needs include improving retention rates, improving graduation rates, and increasing recruitment of minority students. The main research question of the MERIT project is how to increase retention of first two-year students in engineering since many bottleneck courses in this early period are taught outside of engineering. Thus, in addressing these needs, MERIT takes a collaborative approach incorporating faculty from the Colleges of Arts & Sciences and Engineering under the leadership of a highly qualified team. The MERIT project consists of two primary components, an Engaging Mentoring and Tutoring (EMT) program and a three-week Summer Research Program (SRP). The EMT tackles the bottleneck courses in the first two-year of engineering curriculum that are taught outside of engineering college. Faculty members from Engineering and Arts & Sciences worked together to create hands-on learning modules involving engineering concepts for selected bottleneck courses. Supervised by the bottleneck course instructors, junior and senior engineering students used these modules to mentor and tutor the first two-year students. The SRP is designed to prepare first two-year students and community college students through project-based research and learning in order to retain and recruit students in engineering fields. Difficult concepts in engineering bottleneck courses were explored through the well-designed three-week research projects in different disciplines. First two-year students trained in the EMT program and community college students were recruited to participate in the SRP every year. In this paper, the

authors focused on how to design the EMT and SRP programs to increase their positive impacts on the students, including students' performances, attendance, etc.

2. Program Design and Implementation

The EMT program aims to provide support and guidance to minority students to persist, succeed and progress towards graduation. Twenty junior and senior student mentors (most from engineering majors) and one engineering faculty (co-PI of the MERIT project) worked with those bottleneck course instructors to develop and improve at least 10 hands-on course learning modules with engineering concepts for each course in every semester. After trained by MERIT project team and course instructors, student mentors provided peer mentoring and tutoring to the students in the bottleneck courses. The SRP aims to improve students' ability to think critically in science, technology, engineering and math, and to succeed in upper-level classes. The SRP provides academic preparation to first two-year college students through project based learning with focus on difficult principles and concepts identified from first two-year college STEM courses. Each SRP team consists of one faculty advisor, one student mentor, and 3-6 SRP participants. The entire MERIT project design structure is shown in Figure 1.

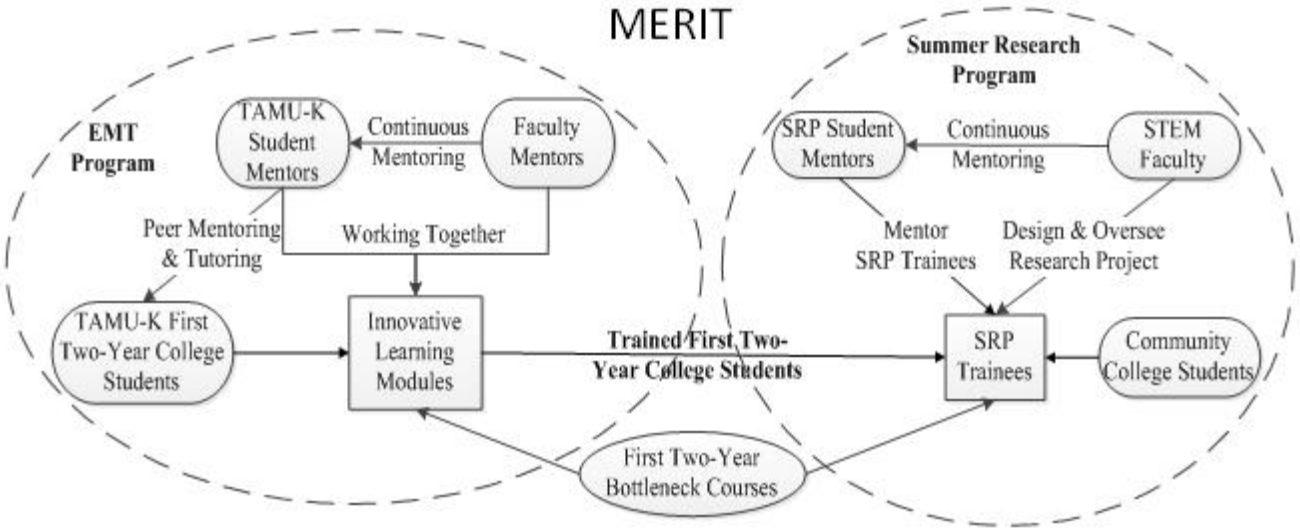

Figure 1: MERIT project design structure

As originally planned, the first year of the MERIT project was mainly for project initiation and development, and the second and third year were designed for fully implementation and continuous improvement. Table 1 shows all the bottleneck courses chosen in the MERIT project. In the first year, only three courses were selected as the initial targeted bottleneck courses, while all of the three courses were also selected in the following two years. In the second year, three more courses were added to fully utilize the resources of MERIT project. In the last year, Algebra and Physics II were removed based on students' feedback and the limited capacity of hired student mentors. Differential equations course was added in order to test the effectiveness of the EMT on a high level math course. The EMT course module development procedures are shown in Figure 2.

Table 1: Bottleneck courses selected in the EMT

Year	Bottleneck courses chosen in the EMT
Year-1	MATH 1316 Trigonometry, PHYS 2425 Physics I, CHEM 1311 Inorganic Chemistry I
Year-2	MATH 1314 Algebra, MATH 1316 Trigonometry, MATH 1348 Analytical Geometry, PHYS 2425/2426 Physics I/II, CHEM 1311 Inorganic Chemistry I
Year-3	MATH 1316 Trigonometry, MATH 1348 Analytical Geometry, MATH 3320 Differential Equations, PHYS 2425 Physics I, CHEM 1311 Inorganic Chemistry I

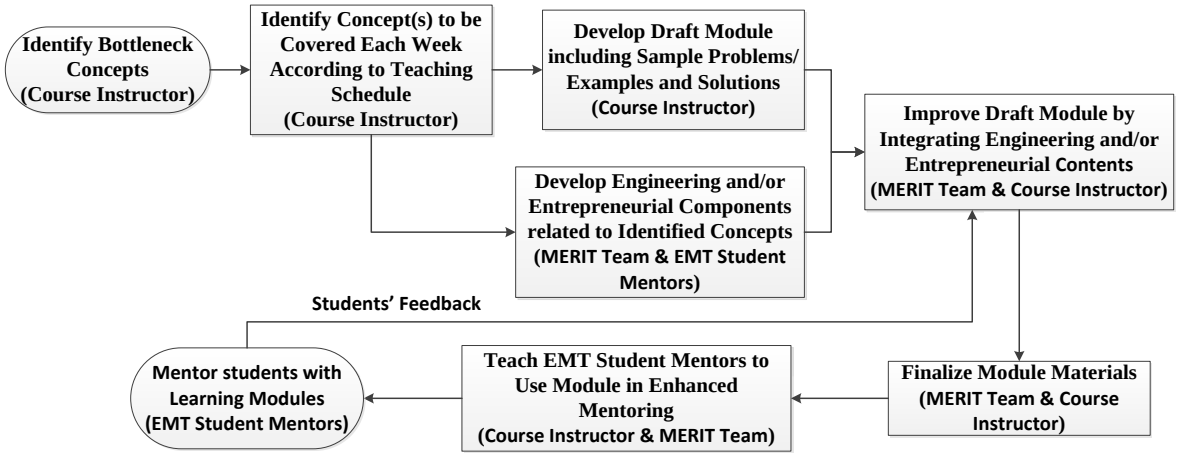

Figure 2: EMT course module development procedures

In the SRP, six projects were chosen in the first year. However, due to budget limitation, there were only five projects chosen in year 2 and year 3. The selected SRP projects are listed in Table 2 together with year implemented and concepts addressed. Each project team completed weekly progress reports, a final project report, poster and final presentations.

Table 2: SRP project lists with concepts addressed

SRP Project Titles and Year Implemented	Specific Concepts/Fields Addressed
Chemical Process Simulation (year 1-3)	Chemical and Natural Gas Engineering
Design and Optimization of Active Disassembly Using Smart Materials (year 1-3)	Materials Science and Product Design in Mechanical Engineering
Wind Mill and Wind Farm Design (year 1-3)	Aerodynamics and Product Design in Mechanical Engineering
Nano Chemistry (Year 1-2)	Chemistry and Materials Sciences
Understanding and Measuring Physical Quantities in Athletic Performance (year 1)	Physics and Engineering Measurements
Modeling Real World Problems with Trigonometry (year 1)	Calculus II and Engineering Measurements
Discrete Dynamical System (year 2)	Calculus III
Hybrid Energy (year 3)	Chemistry, Materials Sciences, and Product Design
Mathematical Modeling (year 3)	Calculus III

3. Program Results and Discussion

In this section, the students' performance and survey results of the EMT (Spring 2015/Fall 2015/Spring 2016) and the SRP (Summer 2015/Summer 2016) in year 2 and 3 were analyzed and discussed in detail. Due to time constraint, the Fall 2016 EMT survey data is still in processing, and is not included here. The general results of the EMT and the SRP programs were presented first, while detailed analysis based on voluntary surveys in both EMT and SRP programs were discussed later. In the first year, the EMT's outcomes indicated a moderate effectiveness based on students' participation and survey results [7]. This is expected since most of course modules were still under development during the first year.

In Spring and Fall 2015, 38% of the students in the EMT courses increased their grades from mid-term to final, while 37% maintained their mid-term grades to their final. There were 82% of the students in the EMT courses received credits, which was significantly increased compared with baseline data (around 45%-50% in year 2012). In Spring and Fall 2016, 74% of the students in the EMT courses received credits. Considering Differential Equations course was added in year 3, the reduction in passing rate was expected.

In Summer 2015, 18 students from different community colleges and four-year universities participated in the SRP. In Summer 2016, 27 students from different community colleges and four-year universities participated in the SRP. The matriculation rate of students who participated in the SRP and transitioned to TAMUK was increased by 11%. In addition, 55% of the students who were enrolled in community colleges were transferred to a four year institution.

Voluntary surveys were conducted in both EMT and SRP. The numbers of completed responses were listed in Table 3. The survey response rate in the EMT was about 70%, while it was about 90% in SRP. In the completed EMT responses, there were 63% male and 37% female students, while 65% were Hispanic students and 35% were non-Hispanic students. In the completed SRP responses, there were 83% male and 17% female students, while 72% were Hispanic students and 28% were non-Hispanic students. Most of the questions in both EMT and SRP surveys were scale based with five answer options from strongly disagree to strongly agree. The answers with agree and strongly agree were considered positive feedbacks in this paper. However, the comparison analysis of students' performances between those participated in the SRP/EMT and those not participated was not included in this paper since the data collection is still in process.

Table 3: The number of completed survey responses

Survey	EMT			SRP (pre/post)	
	Spring 2015	Fall 2015	Spring 2016	Summer 2015	Summer 2016
Completed responses	179	256	294	16/11	26/25

Several questions related to the overall effectiveness of the EMT were first analyzed, and the results were shown in Table 4. It could be concluded that most students agreed the EMT had positive impact and the EMT faculty and student mentors were well prepared.

Table 4: Results of students' positive responses in selected survey questions

Questions	Spring 2015	Fall 2015	Spring 2016	Total
Attending EMT helps improving course grade	68.8%	65.5%	74.5%	70.0%
Attending EMT helps understanding course materials	72.5%	68.7%	73.2%	71.4%
EMT mentors are well prepared	73.1%	69.5%	73.5%	72.0%
EMT mentors provide suggestion and tools to better approach course assignments	71.5%	66.7%	72.5%	70.3%
Instructors use real world examples	81.6%	77.7%	80.9%	80.0%

However, there were still about 20%-30% of the students who did not agree the EMT had positive impact. One of the reasons may be those students did not attend the EMT or only attended a few times. The attendance results from students' surveys were shown in Table 5. It should be noted that some students did not answer this specific question, so the total percentage was not added up to 100% in Table 5. About 15% of the students never attend any EMT session, while about 20% of the students only attended special review sessions designed for exams. About 40% of the students regularly attended the EMT sessions (three or more times per month).

Table 5: Attendance results from students' survey

Attendance	Spring 2015	Fall 2015	Spring 2016	Total
Never	16.5%	15.6%	13.5%	15.0%
Only for review sessions	21.3%	21.9%	15.7%	19.4%
Once or twice a month	29.9%	15.6%	18.9%	20.3%
Three or four times a month	17.7%	20.3%	16.0%	18.0%
More than four times a month	14.0%	21.1%	35.9%	25.4%

By comparing the results in Tables 4 and 5, it could be concluded that most students who attended the EMT sessions thought the EMT had positive impacts. In another word, the EMT session itself was well designed and had positive impact. The key issue is to encourage more students attending the EMT session regularly, since the attendance is a very important factor for most mentoring and tutoring programs [8-9]. Several factors were first considered to be related to students' attendance to the EMT sessions, including 1) course instructor encouraged use of the EMT or not, 2) EMT mentors' availability and locations were announced in classroom or not, and 3) Tutoring location was adequate or not. Since the attendance results and the three factors were all in five different scales, a multinomial logistic regression with alpha = 0.05, instead of a linear regression, was conducted using SPSS software to analyze the likelihood ratios between students' attendance and the three factors. In the multinomial logistic regression, attendance results were used as dependent variable, and the three factors mentioned above were used as covariates. All three factors were identified as significant factors with p-values and chi-square values of 0.013 (14.456), 0.028 (12.543), 0.003 (17.708), respectively. The multinomial logistic regression results indicated that the attendance would be likely increased if 1) course instructor encouraged use of EMT more frequently, 2) EMT mentors' availability and locations were announced in the classroom more frequently, and 3) tutoring locations was more adequate. The

results also supported what had been done by the MERIT team in order to promote the EMT in the classes:

- Course instructor encouraged students to attend the EMT by including it in the course syllabus and announced it in the first week.
- MERIT project team visited classroom and announce the EMT in the first week.
- At least one EMT mentor sitting in the classroom every week and provided students with latest EMT session hours and locations.
- A big classroom designated to the EMT program with comfort sitting, desks, computers, printers, and scanners.

Since the MERIT project focused on minority students (especially Hispanics) and female students, the responses from Hispanic (64.7%) and female students (31.5%) were also analyzed. Compared the results shown in Table 6 with previous results shown in Tables 4 and 5, there was no significant difference between Hispanic or female students and the average survey results.

Table 6: Survey results from Hispanics and female students

Questions	Hispanics	Female
Attending EMT helps improving course grade	69.0%	65.6%
Attending EMT helps understanding course materials	71.6%	68.8%
EMT mentors are well prepared	71.5%	65.2%
EMT mentors provide suggestion and tools to better approach course assignments	69.9%	63.8%
Instructors use real world examples	78.8%	80.3%
Attendance		
Never	15.0%	12.4%
Only for review sessions	19.8%	22.9%
Once or twice a month	17.3%	13.8%
Three or four times a month	18.0%	20.2%
More than four times a month	23.9%	23.9%

For the SRP, the survey data from Summer 2015 and Summer 2016 were analyzed. Different with EMT survey, there were pre and post surveys conducted in the SRP. The summarized survey results were shown in Table 7. By comparing the pre and post survey results, it could be concluded that the SRP had positive impacts on students' opinions related to STEM.

Table 7: Positive students' responses in selected SRP survey questions

Question	Pre 15	Post 15	Pre 16	Post 16	Pre Total	Post Total
Gain confidence and enthusiasm toward STEM	12.5/81.3	9.1/90.9	26.9/73.1	44.0/56.0	21.4/76.2	33.3/66.7
Faculty uses real world STEM examples	18.8/75.0	0.0/100.0	15.4/84.6	8.0/88.0	16.7/81.0	5.6/91.7
Improving STEM skills will help career goal	12.5/81.3	18.2/81.8	19.2/80.8	24.0/76.0	16.7/81.0	22.2/77.8
Taking advantage of SRP is important to success	6.3/87.5	0.0/100.0	7.7/88.5	32.0/68.0	7.1/88.1	22.2/77.8
Faculty is enthusiastic about STEM	25.0/68.8	0.0/100.0	30.8/65.4	12.0/88.0	28.6/66.7	8.3/91.7
Have better understanding of importance of STEM	18.8/81.3	0.0/100.0	11.5/88.5	24.0/72.0	14.3/85.7	16.7/80.6

* Data shown in percentage (agree/strongly agree)

4. Conclusion

Based on the results above, both EMT and SRP program has positive impacts on the students. Similar as previous researches [10-11], the support from faculty members who teach those EMT courses is extremely critical to the success of the EMT program since it is not a mandatory program for the students to attend. Incentives from instructors encouraged much more students attending the EMT sessions [12-13]. The peer mentoring provided by senior students in both EMT and SRP were also effective [14]. For the SRP, the involvement of faculty advisors and the interaction between faculty advisors and SRP participants are very important to improve the students' experiences in the SRP [15]. Although each SRP team has a senior student mentor, most SRP participants expressed that the interacting and communicating with faculty advisors were the most valuable experiences they gained.

In the three-year MERIT project, some valuable experiences/lessons have been learning that could help similar programs in other universities. First of all, it is important to make sure the project's goals are in line with the university's core values, which is one of the important reasons to make MERIT successful. There is a critical need for activities that engage, challenge and support all students, especially minority and female students as a model for our minority students to persist in their science and engineering studies, graduate and be well-prepared to join the workforce. Second, the continuous advising, training and individual mentoring from the faculty to the mentors will increase the retention rate of student mentors in the MERIT project and in their STEM related field of study. Third, different additional approaches as described below can help improving the program's impacts.

1) With the creation of the MERIT Facebook page, the MERIT project team added helpful links for students to access as an additional form of resources to increase visibility and to emphasize to MERIT mentees how MERIT can assist them with the difficult bottle-neck courses identified.

2) MERIT was further recognized on campus through the university Twitter app. Students who were being tutored were commenting on how great the program was and would give “shout outs” to mentors.

3) Another important approach implemented was increasing the number of times the MERIT PI’s and the MERIT project manager met with the faculty members from once per month to twice per month. This increased the levels of communication between everyone to ensure the success of MERIT. MERIT project team was consistently informed of all aspects occurring in the classrooms with the mentors’ progress and of the mentor/tutor sessions.

4) The Co-PIs and project manager also attended the bottle-neck courses once per month to advocate for the program and highlight the successful outcomes MERIT has had. Business cards with the mentors name, location, tutor schedule, and bottle neck course subject email addresses were created as a general means of communication between the mentor and student. As a result, this has increased the number of students who attended tutorials.

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