Strategies for increasing enrollment, retention, and graduation in two baccalaureate degree STEM programs: Mechanical Engineering Technology (MET) and Safety Management (SM)

Dr. A. Mehran Shahhosseini, Indiana State University

A. Mehran Shahhosseini is a Professor in the Department of Applied Engineering and Technology Management and director of the PhD Program in Technology Management at Indiana State University. He has published over 50 articles in different journals and conference proceedings. He has served as an investigator for research projects sponsored by National Science Foundation, Ford Motor Company, and the US Army. Before working at Indiana State University, he was a faculty in the University of Louisville for 10 years. He also has over four years of industrial experience. He received his D.Eng. degree in Mechanical Engineering from Lamar University (USA) in 1999, M.Sc. in Materials Engineering from Isfahan University of Technology in 1991, and B.Sc. in Metallurgical Engineering from Tehran University in 1988. He is a member of ASEE, ASME, and ATMAE.

Dr. Farman A. Moayed, College of Technology, Indiana State University

Dr. Moayed is an Associate Professor in the College of Technology in Indiana State University since 2008. He received his BS in Industrial Engineering from Sharif University of Technology, Iran and MS and PhD from University of Cincinnati. Dr. Moayed has been teaching occupational safety courses such as fire protection, industrial hygiene, ergonomics and human factors at graduate and undergraduate levels. He has research and publications in human factors and ergonomics, maintenance management, artificial neural network modeling.

Dr. Alister McLeod, Indiana State University

Alister McLeod is an Associate professor at Indiana State University in its Applied Engineering Technology Management department. His research interests span the widespread adoption of operational improvement strategies as well as technologies in the manufacturing sector. Previously, his research has made contributions to the sustainability of lean improvement strategies for first time implementers. In essence, his research aids in the training of a modern manufacturing workforce to cope with both internal and external competitive pressures.

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Work-in-Progress: Strategies for increasing enrollment, retention, and graduation in two baccalaureate degree STEM programs: Mechanical Engineering Technology (MET) and Safety Management (SM)

A. Mehran Shahhosseini*, Farman Amin Moayed, and Alister McLeod

Department of Applied Engineering and Technology Management, Indiana State University, Terre Haute, IN 47809, USA

*Corresponding author, email: mehran.shahhosseini@indstate.edu

Abstract

This article presents a proactive recruitment and support strategy geared towards increase enrollment, retention, and graduation in baccalaureate degree Engineering Technology programs. The strategy aims to institutionalize recruitment techniques of low-income and talented students, increase participation of students from under-represented groups including females and also increase co-curricular activities. Recruitment is the initial component of the strategy and it is pegged to the provision of rich educational experiences and scholarships. Experiences provided are based on a strong professional and supportive network of industry partners that work alongside faculty in creating learning environments that are typical of a particular occupation. To engage students the inclusion of the following activities are paramount: 1) creating a strong cohort framework for students, 2) developing mentor relationships, and 3) hosting co-curricular activities to promote interaction, learning, and exchange. Student support is aimed to create a strong network that connects students to each other and their faculty, the college, and the institution as a whole. This is the main drive of increased participation and once this is complete then students are expected to start engaging in co-curricular activities. These activities are the participation in industry forums and guided industry tours, internships or cooperative work experiences, soft skill honing geared toward career readiness. These activities are undertaken so that job placement in a chosen career occurs upon graduation. New opportunities for professional interactions with the industry partners will help integrate the undergraduate experience with the real-world workplace, resulting in enhanced focus, interest, and success for the students. In this paper, we present a theoretical model that holistically approaches recruitment, retention and employment in baccalaureate degree Engineering Technology programs.

Introduction

In the U.S., a tremendous job growth is expected in STEM occupations through 2024 [1]. According to the Indiana Department of Workforce Development (DWD, 2014), it is projected that up to 123,660 jobs in STEM fields will need to be filled by 2022 within the state. . This project could be a big contributor of making graduates ready for jobs in STEM areas by year 2024.

The DWD projects health and safety engineers (excluding mining safety) to have a significant increase of 15.1% by 2022 [1]. Also, the U.S. Bureau of Labor Statistics (BLS) has projected that the safety jobs (all occupations within this category, including mining safety) will have 46,507 job openings due to growth and replacement needs between 2014-2024. As a result, the BLS expects the total jobs in all occupations of safety to reach 160,329 by 2024. Accordingly, the typical entry-level education for health and safety engineers (excluding mining) and mining and geological engineers is, and projected to remain, a bachelor's degree [1].

The proposed project has specifically targeted the MET and SM majors to meet a burgeoning need projected by the industry for versatile mid-level manufacturing employees with skills and knowledge beyond that of a technician, yet not as advanced as an engineer. With the emerging statewide community colleges meeting demand for two-year vocational training and excellent four-year engineering programs at several reputable institutions in the state, ISU has quickly recognized a void in the preparation of employees with the appropriate training for mid-level manufacturing positions [2].

Not surprisingly, the Indiana Institute for Working Families (IIWF) report [3] recommends aligning education systems with economic development initiatives. Advanced manufacturing and engineering disciplines have key roles in the state of Indiana and the nation's economic growth. By increasing the number of graduates in both MET and SM, this project supports and enhances the economic growth within the state and nationally. Also, being involved in the co-curricular activities and industry partnerships will help the students improve the very skills the workplace demands and build on the initial support provided by the scholarship to produce highly employable graduates.

Background

In fall of 2009, ISU was awarded its first S-STEM program (NSF #0966219) and initially had an undergraduate enrollment of 870 for the College of Technology (COT), which comprised 10.3% of ISU's total undergraduate enrollment. By fall 20172016, the total COT enrollment more than doubled to 2,191 students. (See Table 1). This is a 151.8% increase for COT compared to a 37.0 %increase for the whole ISU campus. Furthermore, over the same period, the total enrollment of female undergraduate students and minority undergraduate students has also seen substantial increases, nearly 48% and 97% respectively

At a time when many institutions are struggling to maintain or slowly shrinking in their enrollment numbers, ISU has been fortunate to see increases in its STEM enrollments every year. Some of that success can be attributed to ISU's concerted efforts to keep tuition increases low. For instance, in 2009, an in-state, full-time student would have paid $7,226 in tuition and in the academic year 2016-17, a full-time student has paid $8,547 in tuition. These modest tuition rates reflect approximately a 3% increase each year since 2009. Although, a relatively smaller increase in percentage, it has outpaced Indiana's annual per capita income and the financial impact of tuition increases is clearly reflected in the growing number of enrollments of students who qualify for financial assistance. Specifically, 40.1% of ISU's total undergraduate population has received federal Pell grants in fall 2017 [4] (see Table 1).

Table 1: Undergraduate Enrollment Comparison

	Fall 2009	%	Fall 2017	%	Increase (%)
Total University Undergraduate Enrollment	8,460		11,591		
Female Students	4,284	50.6	6,347	54.8	48
Minority Students	1,641	19.4	3,229	27.9	97
Total COT Undergraduate Enrollment	870		2,191		
Female Students	140	16.1	459	20.9	152
Minority Students	106	12.2	457	20.9	228
Low-Income Students based on Pell grants	3,035	35.9	4,653	40.1	53

Table 2 shows the portion of students in the MET and SM programs who have received Pell grants and have unmet needs from the 2010-2011 to 2016-2017 academic years. Some numbers in this table overlap (i.e., there are some students who receive Pell Grant and still have Unmet Needs).

College affordability and job placement are becoming critical factors for high school students as they make their career plans [5]. According to a student loan provider, in 2012, 70% of families eliminated college choices based on the cost of tuition/attendance. The amount of money that students are supplying towards tuition between student income and borrowing is 30% of the total annual cost. This number increased by 24% from 2008 to 2012. Parents paid up to 37% in 2012, which was down from 45% in 2008 [6].

Table 2: STEM and non-STEM students in MET and SM programs who received Pell Grants and/or have Unmet Needs (source: ISU Financial Aid Office)

		2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18*
MET	No. of Pell Grant Recipients	3 (33%)	10 (29%)	12 (24%)	15 (29%)	21 (35%)	19 (38%)	27 (46%)
	No. of Students with Unmet Needs	3 (33%)	16 (46%)	16 (33%)	23 (44%)	27 (46%)	31 (62%)	31 (53%)
	No. of Freshmen Admissions	9	35	49	52	59	50	59
SM	No. of Pell Grant Recipients	2 (29%)	4 (25%)	5 (26%)	9 (56%)	7 (29%)	9 (41%)	4 (24%)
	No. of Students with Unmet Needs	3 (43%)	5 (31%)	8 (42%)	9 (56%)	7 (29%)	11 (50%)	6 (35%)
	No. of Freshmen Admissions	7	16	19	16	24	22	17

* Fall semester only.

The recruitment and retaining of underrepresented low-income students has always been a challenge at Indiana State University. To address this issue an NSF S-STEM grant was sought and obtained in 2010 (NSF #0966219). Sycamore Technology Academies & Recruitment Scholarships (STARS) was created and used to award scholarships to students enrolled in Mechanical Engineering Technology (MET) and Computer Engineering Technology (CET) programs over a five-year period. STARS targeted 26 students through: a) a strategic outreach campaign to recruit eligible underrepresented students; b) a suite of enhanced program activities to improve student support, persistence, retention, and graduation rates, c) a diverse project management team with content area expertise; and d) an external evaluation. Among the 26 scholarship recipients, one was a transfer student and nine were females. To be considered for the scholarship, students were required to have a minimum grade point average (GPA) of 2.8 or

higher (on a 4.0 scale) and an estimated financial need of $5,000 or more. The scholarship recipients were enrolled full-time and were either U.S. citizens or permanent residents.

Deploying STARS resulted in a dramatic improvement in student outcomes for the MET and CET programs. Specifically,

- MET undergraduate enrollment grew from 126 students in fall 2010 to 290 in fall 2016 and CET undergraduate enrollment grew from 53 in fall 2010 to 95 students in fall 2016,
- MET female undergraduate enrollment grew from 10 in 2011 to 24 in 2016, and CET female undergraduate enrollment has gone up and down and is currently at 7,
- MET minority enrollment grew from 26 in 2011 to 62 in 2016, and CET minority enrollment grew from 7 in 2011 to 30 in 2016,
- the two-year retention rate has stayed level at 62% in both programs.

The initial STARS grant allowed for the design and implementation of a second version which focused on student recruitment in the Mechanical Engineering Technology (MET) and Safety Management (SM) programs.

Problem

This paper focuses on strategies that involve increasing the numbers of graduates in two baccalaureate STEM programs on campus: Mechanical Engineering Technology (MET) and Safety Management (SM). In comparison with the STARS grant, we replaced CET with SM because of lower numbers of students that were of underrepresented low-income backgrounds. By working with the SM program the impact of the project could be assessed on a new program that has never adopted such a strategy. In addition to the activities done in STARS grant, the project sought to undertake a variety of curricular and co-curricular activities that were not just aimed at recruitment but also that retention. Also, a rigorous research–to-practice plan is being added and the inclusion of an external evaluation to formatively and summatively evaluate the project.

Purpose

Both MET and SM programs offer curricula and co-curricular opportunities that aid in addressing Indiana's high and continuously increasing workforce needs in the technology industry. Therefore, the specific objectives of the project were to:

1. 80% retention rate during each scholarship recipient's first two years. The project's financial support will provide recipients with an opportunity to focus solely on their academics. This support, particularly in the first two years of their program when students complete the "gateway" courses, such as MATH and PHYS, is critical in helping them persist in the program.
2. Increase the participation of students from under-represented groups in MET and SM programs. During the STARS project, there were a total of eight female students. The recommended project will actively recruit under-represented students (including minimum of 12 female students) in the program.
3. Increase the co-curricular activities. Based on the STAR grant's experience, this scholarship project will provide recipients with more activities.

The proposed activities will enhance recruitment with a focus on developing a context of student support in these programs. The team will provide rich educational experiences for a group of talented students and offer them scholarships to enable increased access to STEM education and help build a strong professional and supportive network of industry partners, employers, faculty, and staff members. To further increase workplace relevance, the project will engage students in industry forums, field trips, internships or cooperative work experiences, and provide opportunities for professional skills development. The industry-employer relationships are expected to be beneficial to the students by providing opportunities to gain work experience, develop soft skills, and become "work ready" upon graduation. By creating opportunities for professional interactions, the project will build a bridge between the traditionally isolated undergraduate experiences by providing them with an authentic experience in the industry environment. Successful integration of workplace and education is expected to result in increased focus, interest, and success for all our students [7]. These experiences are also expected to positively affect course curriculum and teaching effectiveness through increased feedback by students and industry [7].

The MET and SM curricula are rigorous, as both programs are math and physics intensive and are considered STEM programs. Both of them require courses such as (but not limited to) algebra, calculus, chemistry, physics, probability and statistics, industrial hygiene, human factors and ergonomics, fire protection systems, system safety analysis, hazardous material management, introduction to solid modeling, applies statics, technical graphics, dynamics, applies mechanism, fluid power technology, and advanced CAD concepts. For this reason, this project is ideally positioned to attract talented under-represented students to ISU. When comparing the average Math SAT scores for Indiana students (499) and ISU students (430), ISU students' scores have been significantly lower than the average for all Indiana test takers [8]. Through this project, ISU will be able to attract more talented, low-income students and thereby equip them with the academic and technical skills needed to address the current and future workforce needs of the thriving manufacturing technology industry.

Table 3: Enrollment Trends in Undergraduate MET and SM Programs
(source: ISU Admission Office)

Major	Student Group	Academic Year (Fall, Spring, Summer)						
		2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
MET	Total*	185	229	280	315	305	290	286
	Transfer	32	30	50	44	53	50	58
	1st-Time Freshmen	36	58	51	37	37	29	32
	Female Students	10	9	16	20	21	24	34
	Minority Students	26	29	47	60	66	62	58
	Others	81	103	116	154	128	125	104
SM	Total*	101	111	126	123	112	110	104
	Transfer	15	7	17	10	8	20	9
	1st-Time Freshmen	13	21	15	8	12	10	13
	Female Students	11	10	10	12	10	13	12
	Minority Students	10	9	7	11	9	11	11
	Others	52	64	77	82	73	56	59

* includes full- and part-time students.

Method

Retention is a recognized indicator in college student progress toward completing a degree [8]. As shown in Table 4, two-year retention rates in the MET and SM programs compare quite favorably to the overall retention rates for the institution and COT, but still there is room for improvement. We expect two-year retention to improve in both programs and hold each year above two year average percentage in the cohorts. The project management team will closely monitor student progress and assemble teams of student and faculty to address problems as they occur.

Table 4: Two-Year Retention Rates, 2014 and 2015 Cohorts (source: ISU Admission Office)

	2014 (%)	2015 (%)	2 Yr Average %
ISU	52.08%	52.00%	52.04%
COT	64.09%	61.56%	62.83%
MET	65.71%	58.33%	62.02%
SM	71.43%	63.46%	67.54%

To help better prepare students for the rigorous coursework related to their majors, we plan to accomplish the followings:

- Address Developmental Math and Physics Needs. Many students begin their freshmen year unprepared for college-level coursework. This is a major stumbling block that often leads to students having to take remedial classes that do not count toward their major that delays their graduation, and extends the amount of time and money towards degree completion. As a result, some students drop out. We experienced in the STARS grant that even the talented students need better math and physics preparation; therefore as part of this project, a plan is to develop remedial math and physics courses that align with required math and physics courses for both MET and SM programs. Also a new interdisciplinary STEM freshman learning cluster will be developed for the students that will focus on problem-solving and inquiry. Additional support will also be provided through peer tutoring opportunities to be developed through this project. We allocate some incentives to the volunteered tutors, as shown in the budget sheet.
- Design Co-curricular Activities for MET and SM Scholars. To provide students work-ready skills and knowledge base, we propose to integrate a portfolio of activities open to students receiving the S-STEM-supported scholarships into their coursework. These activities include many training seminars that will lead to industry-endorsed credentials, opportunities to attend STEM-related conferences and competitions to expand students work experience and career network system, and opportunities to develop soft skills. ISU will leverage existing arrangements and collaborations as well, its location proximity to potential employers, and its status as doctoral/research university to realize these activities.

Frame Work of the Project

- Development of MET and SM baccalaureate degree programs

The degree programs in MET and SM were created largely in response to industries' need for well-trained mid-level employees. As such, each program's curriculum covers a blend of theoretical and applied knowledge to bridge the gap between two-year degrees and four-year engineering degrees. Reshaping the program's' direction, as evidenced by the name change and the application for the ABET accreditation, demonstrates faculty's commitment to continuing to

adapt the programs to the ever-changing overall economic and educational environment, and to prepare students with an education for employment or a pursuit of advanced STEM degrees.

- Cross-Discipline Faculty Collaboration

The management team is composed of faculty with mechanical engineering technology, computer engineering technology, safety management, and human resource development and training background. This project offers the opportunity for the faculty to continue to integrate the strengths of the programs and individuals towards providing better educational experience to students.

- Destination

In partnership with one of its outstanding alumni (a STEM professional), the COT created the Destination Success Mentoring Program. Currently, completing its inaugural term, the program seeks to aid female students pursuing areas of study in STEM within the COT. Program participants receive mentorship and professional development to aid in student success and professional/career development. Mentors consist of COT faculty/administrators and industry professionals.

- Management Plan

The PI and Co-PIs bring expertise to project planning, administration, and execution. The diverse ethnic and academic backgrounds of the team make it especially advantageous for the project to attract and interact with eligible and talented student groups. Besides individual roles and functions, the management team will meet monthly to discuss program goals and objectives, progress made, execution issues, if any, and look for solutions.

- Student Selection Process and Criteria

Students will submit an online application with their demographic information including high school transcripts and other academic records. The project management team will use the Low-Income-Based criteria to find eligible candidates and use the Talented-Based criteria to select the recipients, as listed in Table 8. As shown in Table 8, a computer-based test will be used in the selection process. The proposal's PI was one of the awardees of the NSF-STEM TUES program (Advancing Diagnostic Skills Training in the Undergraduate Technology and Engineering Curriculum (NSF award #1140677), 2012-2015). The research team developed an educational software to teach diagnostic skills necessary to identify and solve problems in technical systems. The software was validated and can be used as one of the tools for the student selection. The software enables the users in technology to benefit from personalized, iterative interactions that permit them to design visual maps of a problem and to allow direct and automatic comparison of their visual map to an expert's map. Applicants who are qualified academically will be reviewed by the ISU Financial Aid staff to determine need (an estimated financial need of $5,000 or more). From those applicants, the management team will first offer scholarships to those who are members of historically disadvantaged groups in STEM fields. To the extent possible, the project's scholarship will be distributed evenly between the SM and MET programs. The applicants' selection criteria are detailed in Table 5.

Table 5: Applicants Selection Criteria

Criteria	Area of Consideration	Criteria Measures for the Applicants
Low-Income-Based (Required)	Citizenship/Residency Status	U.S. citizens, permanent residents, or refugee aliens
	Declaration of Major and Full Time Status	Declaration of major in one of the STEM programs (MET or SM)
	Financial Need *	Full-time degree-track students
Talented-Based (Weight% for the Selection)	High School Academic Performance (20%)**	Minimum cumulative GPA of 2.8 (on a 4.0 scale), Completion of AP STEM courses and participation in extracurricular and co-curricular STEM-related activities will also be considered
	SAT Score (20%)**	Minimum cumulative score of 800
	Letter of Recommendation (10%)	Two Letters from high school science and math teachers
	Essay (10%)	A short essay to discuss their personal and career goals/interests
	Interview (20%)	The management team will interview all final applicants in person
	Computer-Based Test (20%)	The Diagnostic Skill Training software will be used

* The project will be advertised by the Office of Financial Aid at ISU and students from historically disadvantaged groups and students traditionally underrepresented in STEM fields (e.g., African American, Latino, and Native American students, and female students) will be encouraged to apply to increase diversity.

** GPA and test scores are not always reflective of students' potential for success in STEM college programs. Therefore, the candidates who score slightly below the suggested scores will be considered, as long as they demonstrate strengths in other areas. ISU uses SAT as one of the selection criteria.

Students must be enrolled full-time in the SM or MET program and maintain a 3.0 GPA to retain scholarship eligibility. Scholarship recipients' progress will be reviewed at bi-monthly intervals during each semester to monitor their progress. Those students in danger of not meeting the required level will be counseled by faculty advisor on the team and COT Student Services to determine any problems and will recommend appropriate steps to be taken to return to the path towards success.

- Quality of Educational Programs

The quality and affordability of ISU education have been recognized by national educational services on a regular basis. For twelve consecutive years ISU has been ranked by Princeton Review to be among the 'Best in the Midwest' [9], and in 2015 ISU was listed to be among nation's 'Best Value Colleges' [10] by the same organization. The predecessor program of MET, mechanical design technology had been offering degrees and producing quality graduates since 1978. This program was academically strong and had been continuously accredited by National Association of Industrial Technology (Presently Association of Management, Technology and Applied Engineering) with no major deficiencies. In 2008 COT applied for an ABET accreditation for the MET program and the accreditation was granted in fall 2009. Since launching the MET program in fall 2005, enrollment has increased from 50 (fall 2005) to 255 (fall 2016). In 2015 COT applied for an ABET accreditation for the SM program, and in spring 2016 the accreditation was granted. Although spring 2010 is the first semester for students to enroll in the SM program in COT, enrollment has increased from 69 (spring 2010) to 100 students in fall 2016. With this positive trend, we believe we are on par to meet the enrollment goals for both programs in the next few years.

The courses taught through each program's course of study emphasize both theoretical and technical knowledge and application and are comprised of group learning, projects, and hands-on (laboratory) components. Small class size and low student-instructor ratio provide a more open

atmosphere for both parties to exchange thoughts. The quality of teaching is indicated in part through student evaluations of the program, which consistently rank faculty above 4.0 on a 5.0 scale. Employers who have hired programs graduates also attest to the quality of the programs, as evidenced in letters included in the Supplemental Documentation section of this grant application.

- Dissemination to faculty, staff, administrators, students, and community members

Involvement of students in speaker forums, guided industry field trips, internships or cooperative work experiences, and job placement skills development will increase workplace relevance. New and stronger opportunities for professional interaction will integrate the undergraduate experience with the industry workplace, resulting in increased focus, interest, and success for students. These experiences are also expected to positively affect course curriculum and instruction through increased feedback by students and industry representatives. The project will also utilize ISU's membership in MERLOT (Multimedia Educational Resource for Learning and Online Teaching) for dissemination to educational communities. This resource provides a worldwide distribution point for the components of developed lab projects. Access to the materials in MERLOT is free; participation in the MERLOT community is based on institution membership. Over 38,000 faculty and student members presently subscribe. Through the federated search services, the archive is connected to other libraries of learning objects in a global network. The project's management team will also create an annual newsletter and research posters.

- Dissemination to STEM Educators

The project management team will submit technical articles that discuss findings in peer-reviewed STEM and education journals and conferences. Each year the recipient of scholarship will be asked to compose a short article along with pictures/video (if applicable) describing their experiences at ISU and distribute them online and as pamphlets among local high school students (as outreach materials) to encourage them enter STEM fields.

Timeline

We intend to start the planning phase of the project in the Fall of 2020. This phase will see us engaging the tutoring services at the university to ensure that they will be able to cater to the students we hope to get in the Fall of 2021. In addition, we will be working with the University's honor program to initiate our mentoring program. Towards the end of the Fall 2020 we hope to identify students to enroll in the Fall of 2021 and this process will continue until March of 2021. Developing a management plan with the university concludes phase 1 of the project. In the Fall of 2021 we kick the program off with phase 2. This involves welcoming new participants as teaming them up with mentors and tutors. Data collection begins in earnest during this phase and is concluded at the end of the 2021-2022 academic year. Dissemination then follows for the next two months and this marks phase 3 of the project (See Table 6 below).

Table 6: Project Timeline

	Name	Duration	Start	Finish
1	**Phase 1 -Planning**	**162 days**	**8/18/20 8:00 AM**	**3/31/21 5:00 PM**
2	**Implement developmental Math and Physics Needs**	**7 days**	**8/18/20 8:00 AM**	**8/26/20 5:00 PM**
3	Engage tutoring services	7 days	8/18/20 8:00 AM	8/26/20 5:00 PM
4	**Design Co-curricular Activities for MET and SM Scholars**	**90 days**	**8/18/20 8:00 AM**	**12/21/20 5:00 PM**
5	Initiate Destination Success Mentoring Program	90 days	8/18/20 8:00 AM	12/21/20 5:00 PM
6	**Development Managment Plan**	**108 days**	**11/2/20 8:00 AM**	**3/31/21 5:00 PM**
7	Student identification	108 days	11/2/20 8:00 AM	3/31/21 5:00 PM
8	Setting of project short term goals	60 days	11/2/20 8:00 AM	1/22/21 5:00 PM
9	**Phase 2 - Implementation**	**217 days**	**8/2/21 8:00 AM**	**5/31/22 5:00 PM**
10	Welcome new participants	7 days	8/2/21 8:00 AM	8/10/21 5:00 PM
11	Have designated tutoring	217 days	8/2/21 8:00 AM	5/31/22 5:00 PM
12	Utilization of Destination sucess Mentoring program	217 days	8/2/21 8:00 AM	5/31/22 5:00 PM
13	**Phase 3 - Dissemination**	**60 days**	**6/1/22 8:00 AM**	**8/23/22 5:00 PM**
14	Dissemination to faculty and staff	32 days	6/1/22 8:00 AM	7/14/22 5:00 PM
15	Dissemination to STEM educators	60 days	6/1/22 8:00 AM	8/23/22 5:00 PM

Conclusion

The project will significantly increase participation of low-income talented groups in MET and SM programs, presenting a model for increasing recruitment, retention, and graduation in other technology disciplines. The recruitment will be based on SAT scores, proof of socio-economic status, a computer-based test and other academic criteria. Students will develop valuable teamwork and networking skills that will enhance their contributions to the workplace. Strong involvement of industry representatives in forums, advisory roles, and as mentors will bring immediacy and relevance to the educational experience and build a relationship of feedback and exchange for an ongoing success of the grant. By increasing the number of well-prepared graduates in MET and SM programs, the project will meet growing needs of the rapidly expanding high technology industry in Indiana and surrounding states.

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