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Experiences of students supported by an NSF S-STEM grant in a Robotics and Mechatronic Systems Engineering program

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Dr. Shuvra Das started working at University of Detroit Mercy in January 1994 and is currently Professor of Mechanical Engineering. Over this time, he served in a variety of administrative roles such as Mechanical Engineering Department Chair, Associate Dean for Research and Outreach, and Director of International Programs in the college of Engineering and Science. He has an undergraduate degree in Mechanical Engineering from Indian Institute of Technology, Kharagpur, and Master's and Ph.D. in Engineering Mechanics from Iowa State University. He was a post-doctoral researcher at University of Notre Dame and worked in industry for several years prior to joining Detroit Mercy. Dr. Das has taught a variety of courses ranging from freshmen to advanced graduate level such as Mechanics of Materials, Introductory and Advanced Finite Element Method, Engineering Design, Introduction to Mechatronics, Mechatronic Modeling and Simulation, Mathematics for Engineers, Electric Drives and Electromechanical Energy Conversion. He led the effort in the college to start several successful programs: an undergraduate major in Robotics and Mechatronic Systems Engineering, a graduate certificate in Advanced Electric Vehicles, and a thriving partnership for student recruitment with several universities in China. He has also been the dissertation advisor for and graduated many Ph.D. students. Dr. Das's areas of research interests are modeling and simulation of multi-disciplinary engineering problems, modeling multi-physics problems in manufacturing, engineering education, and curriculum reform. He has worked in areas ranging from mechatronics system simulation to multi-physics process simulation using CAE tools such as Finite Elements and Boundary Elements. He has authored or co-authored five books on these topics.

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Experiences of Students supported by an NSF S-STEM grant in a Robotics and Mechatronic Systems Engineering program

Abstract

In 2012 University of Detroit Mercy, an urban institution, launched a new engineering major in Robotics and Mechatronic Systems Engineering. This multidisciplinary engineering program evolved out of collaborative efforts of Mechanical and Electrical Engineering faculty members in this institution around the theme of Mechatronics and Robotics. Several NSF grants helped develop a lot of these prior work in the early 2000s. These efforts served as the platform that enabled the launching of the program in 2011 [1,2]. In 2016 the program received ABET accreditation with the graduation of the first cohort of Students. In 2016 more NSF funding, in the form of an NSF S-STEM (Scholarships in Science, Technology, Engineering and Mathematics) grant, was received to help recruit needy Students in the program and offer them scholarships for four years so that they can successfully complete the new degree. Seven Students were recruited in the first year of the grant and nine more in the subsequent years to fill the total promised number of sixteen. Between the scholarships received from the institution and the NSF scholarship 100% of the tuition was covered. The group recruited was a diverse one consisting of 11 first generation Students whose parents do not have college degrees, five Hispanic Students, three African Americans, and six female Students. The S-STEM grant is going to officially end at the end of this academic year. Seven Students have already graduated and are employed in their disciplinary area. Two more Students are scheduled to graduate this year. The rest will graduate at the end of next year.

Research by Sara Goldrick-Rab [3] has demonstrated that the needs of today's Students in the US is far beyond just the cost of tuition. Poverty, food insecurity, and other societal challenges play major roles in the lives of the modern Student. This paper is about the journey of some of the Students in this NSF-supported cohort. Most of these Students are closer to the end of their undergraduate program rather than the beginning. Instead of providing only statistics we have delved into the details of these Students' backgrounds, their high school experience, college preparedness or lack thereof, their college experience, their family needs, demands on their time, demands and support from the educational ecosystem, internship experiences, work experiences, and their overall feeling about the entire experience. Overall, by exploring the journey of these Students we will also gage the level of success (and failure) of the work done with this NSF S-STEM grant.

1. Introduction

The word Mechatronics refers to an interdisciplinary area consisting of mechanical, electrical, electronics and computer technology. The term was originally coined by the Japanese in the late sixties and has been used since then to indicate simultaneous use of multidisciplinary technology for designing a better product. Mechatronics is not necessarily a new discipline but more of a

design philosophy where best available technological solutions are implemented irrespective of their disciplines. To ensure true synergy in the mechatronics approach to design it is important that multidisciplinary solutions are considered at the early stages of the process. This is easier in concept than in reality because our traditional training is in more compartmentalized disciplines such as Mechanical, Electrical or Computer Engineering.

In many modern-day products, the traditional barriers between disciplines have broken down. For example, in automobiles, systems or subsystems that were purely mechanical have been replaced with efficient computers and electronic control that work seamlessly with mechanical components to achieve better efficiency and reliability. The response time, accuracy and efficiency required in modern automobiles are not always achievable by purely mechanical means. Robots are the most well-known examples of mechatronic devices but mechatronic devices are now common in almost all sectors ranging from household consumer appliances to healthcare and defense. For quite some time our industrial partners have been expressing a need for engineers educated in the principles and applications of mechatronics and robotics. In the Detroit area, the auto industry still represents the single largest constituent in University of Detroit Mercy's employer base. In recent years, the inclusion of electronics in many vehicle functions has created the demand for engineers who can design systems with integrated mechanical and electrical components. Vehicle electrification and development of autonomous vehicles are two of the fastest growing activities within the automotive sector. Also, there is a vibrant robotics industry in Michigan, as well as the Army's Joint Center for Robotics Research where a variety of autonomous and unmanned robotic solutions necessary for the army are being developed.

Despite the above realization, until about ten years ago many universities had just developed one or two courses in the area. Over the last ten years many universities in the United States started their own comprehensive mechatronics programs; in Canada, Australia, and Europe, there was always more enthusiasm for the concept of a more integrated curriculum. It should be noted that mechatronics is associated with enough distinctive content to justify a separate degree, following in the footsteps of other non-traditional and interdisciplinary programs such as systems engineering, biomedical engineering, etc. In 2011 at Detroit Mercy, we launched a new undergraduate major on this theme. We named it Robotics and Mechatronics Systems Engineering (RMSE). This was the first such major started in Michigan. Although the name is long and a little unwieldy it was deliberately chosen because the word Robotics can be easily identified by high school Students particularly due to the popularity of competitions such as FIRST Robotics, while employers can better identify with the word mechatronics when they seek prospective employees with certain skills. Our industrial partners' need for engineers trained in mechatronic principles is being met through this undergraduate program in which all basic concepts are taught through rigorous integrated coursework. During the three mandatory co-op terms our Students are able to apply skills learned in classes and design projects to solve real problems at their workplace. Also, seniors work on a two-semester capstone design problem where they learn first-hand how new engineering systems are integrated to meet customer needs.

In 2015 an NSF S-STEM proposal was funded to support up to sixteen Students for four years in this program. This funding helped significantly in the recruitment of Students during the early years of the program. Many of the Students who were supported from this grant have graduated and are employed in their field. Some are still in the program and are progressing well towards their degree. In this paper, we present some of the results and the impact of the grant. Instead of relying just on raw data about the Students we have focused on the stories of individual Students, tracking their journey and exploring their experiences in some levels of detail so that we get to see how the grant changed the life and career of some very deserving Students.

2. RMSE program

The importance of mechatronics as a relevant and vital area of expertise has become widely acknowledged by both academia and industry, as was stated in [4]. In the same article, it was even suggested that perhaps all mechanical engineers should be mechatronic engineers. The author of another article with the attention-getting but perhaps overstated title "The end of the M.E.?" [5] has, in a similar vein, implied that the traditional Mechanical Engineering program needs to be revitalized. That jobs based on just the use of these traditional skills are more likely to be outsourced is a directly stated contention in [5]. This is the promise that mechatronics education brings to the discipline of Mechanical Engineering in the United States.

For the discipline of Electrical Engineering there are similar gains to be realized. Many products of everyday use have a mechanical aspect to them and, furthermore, are associated with some form of electronic and/or control circuitry [5]. Thus, incorporation of mechatronics content broadens the playing field for Electrical Engineers, while directly catering to the ABET requirement of interdisciplinary education in engineering programs.

Figure 1 shows a pictorial representation of the field of Mechatronics depicting the multi-disciplinary nature of technology of the modern times. In order for tomorrow's engineer to be a leader in product development in the area of smart systems they need to have this multi-disciplinary training. Our early work in this area started in late 1990s due to a recognition that multidisciplinary curriculum was an absolute necessity. In order to address this competency gap, a team of faculty members (consisting of faculty from both ME and EE departments) started work in the late nineties with the help of National Science Foundation (NSF) funding to integrate Mechatronics-based activities at all levels of the undergraduate engineering curriculum. The components of the first phase of the project were the development of a new senior level technical elective in introductory mechatronics, and the introduction of mechatronic activities in a freshman design course and in several pre-college programs that the school runs. After successful completion of the first phase, the faculty team received a second NSF grant in 2003 to build on the earlier efforts by developing two new advanced courses in the area of Modeling & Simulation of Mechatronic Systems and in the area of Sensors & Actuators for Mechatronic Systems. This second phase involving the development and delivery of these two advanced courses in mechatronics was successfully implemented within three years. The third phase involved the creation of a Mechatronics area of concentration or minor at both the

undergraduate and graduate levels [1,2,6,7]. Building on all these early activities it was decided around 2010 that the time was right to start a new undergraduate major in this area.

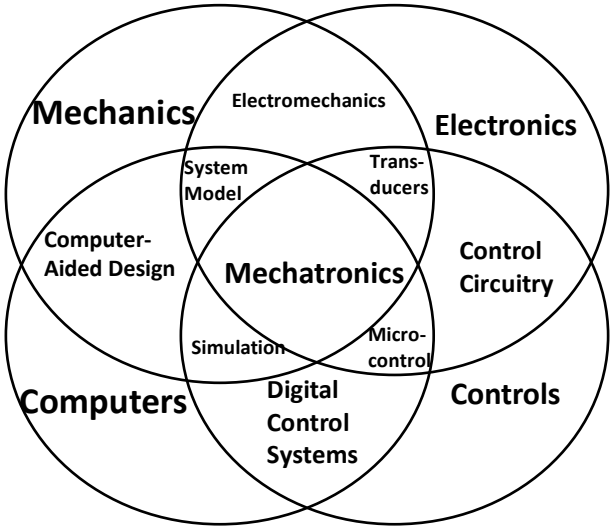

Figure 1: Competency areas for Mechatronics.

The Bachelor of Robotics and Mechatronic Systems Engineering is an undergraduate ABET accredited degree program that is focused on the fundamentals necessary for the design of systems and products in which electronic and computer control of mechanisms, as well as environment sensing and interpretation, are combined to achieve "intelligent" products and environments and "life-like" performance. The program explores what can be considered Cyber-Physical or "smart" systems. Such systems are co-engineered and interacting networks of physical and embedded computational systems that are characterized by the blurring of boundaries between sensors, electronic communication & control, computational systems, and mechanisms. Examples include intelligent and autonomous transportation systems that make travel faster and safer, mobile sensor nets that can perform detailed environmental and pollution tracking, and smart and autonomous robots that will assist with elder care, automate household tasks, undertake customize manufacturing, and explore uncharted, uncertain, or hostile terrain. These hybrid systems all involve multiple modes of operation with different software and hardware elements often distributed across multiple agents.

The Electrical & Computer Engineering and Computer Science Department has deep roots in the fundamental areas that comprise Cyber-Physical systems. This, combined with our highly collaborative College of Engineering & Science, and our cooperative education program, which partners with the world's leading automotive, computer and robotics industries, makes the Robotics and Mechatronic Systems Engineering both highly unique and effective.

This multi-disciplinary program underwent a successful ABET visit for *accreditation* in 2016-17 when its first Students graduated. It provides Students with an in-depth knowledge of engineering science and design methodology in a multidisciplinary context that includes electronics and circuits, embedded systems and controls, and software and hardware integration as well as mechanics and dynamics. By working with hands-on projects from the freshman

through senior years, exploring a series of robotic/mechatronic, sensor, and communication systems, Students combine electrical, computer, and mechanical engineering concepts with practical applications. Then, at multiple points in the four-year program, Students work in industry (a co-op assignment with an engineer's salary; a total of three co-ops is mandatory for graduation) to apply their knowledge and build real work experience. Rather than focusing on dry theoretical topics separately, we teach engineering theory through an integrated and applied approach in system design, so Students learn how concepts work together - as they would in the "real world."

Students also have team-oriented design experiences integrated throughout their curriculum. A capstone design experience, conducted in the senior year, challenges Students with a sophisticated systems-level project that involves the development of intelligent vehicles for entry in national competitions, an assistive-technology product for a real client, or a process-related problem that draws on knowledge from a variety of topics to which they were exposed.

The courses required in the program are listed in three different sub-groups; Engineering Courses for the Major, Engineering Foundation Courses, and University's core courses.

<u>Engineering Courses in the Major (61 credits)</u>

- Introduction to Programming I (3 credits)
- Introduction to Programming II (3 credits)
- Fundamentals of Electrical & Computer Eng I (3 credits)
- Fundamentals of Electrical & Computer Eng I Lab (1 credit)
- Fundamentals of Electrical & Computer Eng II (3 credits)
- Fundamentals of Electrical & Computer Eng II Lab (1 credit)
- Digital Logic Circuits (3 credits)
- Digital Logic Circuits Lab (1 credit)
- Intro to Microcontrollers (3 credits)
- Intro to Microcontrollers Lab (1 credit)
- Signals and Systems (3 credits)
- Hardware and Software Integration (3 credits)
- Electromechanical Energy Conversion (3 credits)
- Vehicle Dynamics* (3 credits)
- Robotics (3 credits)
- Autonomous Mobility Robotics (3 credits)
- Control Systems (3 credits)
- Sensors and Actuators (3 credits)
- Mechatronics Modeling and Simulation (3 credits)
- ECE Senior Capstone Design I** (2 credits)
- ECE Senior Capstone Design I Lab I** (1 credit)
- ECE Senior Capstone Design II** (2 credits)

- ECE Senior Capstone Design II Lab** (1 credit)
- Technical Elective (4000/5000-level course) (3 credits)
- Technical Elective (4000/5000-level course) (3 credits)

Engineering Foundation Courses (59 credits)

- Analytic Geometry and Calculus I (4 credits)
- Analytic Geometry and Calculus II (4 credits)
- Analytic Geometry and Calculus III (4 credits)
- Differential Equations with Linear Algebra (4 credits)
- Applied Probability and Statistics (B2) (3 credits)
- General Physics I (3 credits)
- General Physics Laboratory I (1 credit)
- General Physics II (3 credits)
- General Physics Laboratory II (1 credit)
- General Chemistry I (C1) (3 credits)
- Chemistry Laboratory I (1 credit)
- Engineering Ethics (F1, IT6) (2 credits)
- Basic Engineering Graphics and Design (1 credit)
- Engineering Computing and Problem Solving (1 credit)
- Fundamentals of Engineering Design (2 credits)
- Statics (3 credits)
- Dynamics (3 credits)
- Mechanics of Materials (3 credits)
- Technical Writing (IT1) (3 credits)
- Intro to Engineering & Science Co-op (1 credit)
- Professional Practice of Engineering (C2, IT3) (2 credits)
- Professional World of Work III (or Fundamentals of Engineering Practice) (1 credit)
- Engineering Co-op I (2 credits)
- Engineering Co-op II (2 credits)
- Engineering Co-op III (2 credits)

University Core Curriculum Courses

In addition to the courses required for this program listed above, the Students also must fulfill the University's core course requirements.

3. S-STEM grant Details

The first Student graduated from the RMSE program in 2016. In 2015 we received an NSF S-STEM scholarship grant to support 16 Students in this program for four years. The objectives of the S-STEM project were to attract talented Students, particularly women and minorities, into this new program and increase the number of engineering graduates trained in interdisciplinary engineering through financial help, mentoring, improved Student support, and retention efforts. The long-term strategy included several components: (a) working with the extensive pre-college

program that the college already sponsors to increase the interest of students in engineering disciplines, (b) working with high schools, FIRST Robotics teams and community colleges to attract more students into engineering disciplines, and (c) provide scholarships and academic support to qualified students (particularly women and minorities, and transfer students) who choose this RMSE program as a major. The project plan to achieve the project objectives included some key goals:

- Provide 16 qualified but financially challenged students with funds to enroll as full-time students in the Robotics and Mechatronic Systems Engineering program at UDM. Each student will receive $9000 per year. Seven scholarships will be awarded in the first year and nine in the second. Scholarships will continue for four years, provided the students maintain their eligibility. Therefore, seven and nine students will graduate in the fourth and fifth years of the program, respectively.
- Preference will be given in the following order: 1) economically disadvantaged students, 2) underrepresented minorities, 3) women, 4) transfer students from community colleges.
- Recruitment efforts will include reaching out to the following groups: 1) students who participate in pre-college programs, 2) FIRST Robotics competition participants, and 3) public and private high school and community college students from the greater Detroit area and nationwide.

The grant funding announcement came in August 2015. It was already too late to recruit for that year. In 2016 7 students were recruited. One student dropped out of college by the end of the first year. In 2017 only three students could be recruited (although the target was 9). Of the three, two dropped out in their first year. In 2018 nine more students were recruited to complete the planned roster of sixteen students. By December 2021, seven students have already graduated from the program and are gainfully employed. The rest of the group are at different stages of completion. All the students supported through this NSF grant received $9000 per year. Along with this, they also received an attractive scholarship offer from the university. So, for all of them, between the NSF scholarship and the University scholarship they had no out-of-pocket tuition costs.

4. Students in the program

Table I shows a list of all the students who were recruited for the S-STEM scholarships. Of all the students recruited (a total of 19), four students dropped out of college during their first year. All of them performed very poorly in their freshmen classes before eventually leaving the university. Two students were supported for three years but their support was stopped when their performance kept on getting worse and they changed majors. Seven students have graduated and are working in the automotive industry. The rest of the students are on track to graduate from the program in the near future. Of all the students recruited five are Hispanic, five are African-Americans and the rest are white. There were seven female students in the group. And ten out of the nineteen were first generation students. Their parents either did not attend college or never finished a degree. For the sake of maintaining student privacy only initials have been used in this paper to identify students.

Table I

Student	Gender	Ethnicity W = White H = Hispanic A = African-American	1st Generation?	Start Term	Status	Post-degree plans
Student 1	M	W	Parent attended college but no Bachelor's degree	Fall 2016	Dropped out	
Student 2	M	H	Yes; parents never went to college	Fall 2016	Graduated	Works for General Motors
Student 3	M	H	Parent attended college but no Bachelor's degree	Fall 2016	Graduated; Finished Master's Degree	Works for Fiat-Chrysler
Student 4	F	W	No; parents have degree (s)	Fall 2016	Graduated	Works for General Motors
Student 5	F	W	No; parents have college degrees	Fall 2016	Graduated; Finished Master's Degree	Works for Ford
Student 6	F	H	Yes; parents never went to college	Fall 2016	Graduated	Works for General Motors
Student 7	M	A	One Parent attended college but no Bachelor's degree	Fall 2016	Graduated	Works for General Motors
Student 8	M	A	No; parents have degree (s)	Fall 2017	2022 Winter	Hired by Ford
Student 9	M	W	unknown	Fall 2017	Dropped Out	
Student 10	F	H	No; parents have degree (s)	Fall 2017	Dropped Out	

Student 11	M	A	Yes; parents never went to college	Fall 2018	Not in the program anymore	
Student 12	F	W	Parents attended college but no Bachelor's degree	Fall 2018	Graduated	Works for General Motors
Student 13	F	A	Parent attended college but no Bachelor's degree	Fall 2018	2023 graduation	
Student 14	F	W	No; parents have degree (s)	Fall 2018	2023 graduation	
Student 15	M	W	Yes; parents never went to college	Fall 2018	2023 graduation	
Student 16	M	A	Yes; parents never went to college	Fall 2018	Dropped out	
Student 17	M	W	No; parents have degree (s)	Fall 2018	Not in the program anymore	
Student 18	M	H	Yes; parents never went to college	Fall 2018	2023 graduation	
Student 19	M	W	No; parents have degrees	Fall 2021	2025 gradution	

5. Selected Student Interviews

In this section we have included more details about the journey of some of the students in the program. This should provide a little more information about how the scholarship and the associated support impacted the life and career of these students. Also, this section should provide a glimpse into the diverse background of these individuals.

Student 6

Student 6 is a first-generation college student. She is the oldest of three siblings. Her father works in landscaping and her mother is a food preparer at Detroit airport. Her parents never finished high school. She has a younger sister and a brother. Her sister is a year younger than her and her brother is nine years younger than her. The family is very close knit and the two older children grew up helping out a lot with household work including taking care of the

youngest sibling. Student 6 went to Christo Ray high school, a private Catholic school in Detroit that serves a very diverse population including a large number of middle- and low-income families. Among the students served, a large percentage is Hispanic. Christo Ray is unable to offer a lot of advanced classes but they are very aggressive about getting all their students to apply and get accepted in colleges. They have a strong FIRST Robotics team as well. Student 6 was a leader in her FIRST Robotics team and that is how she got recruited at the University. Although she was interested in Biomedical Engineering the full-ride scholarship for this program was instrumental in her eventually deciding to come to Detroit Mercy and majoring in RMSE program. The first year of college was particularly challenging for her. She feels that the high school classes she had did not prepare her well for college. She had to take many pre-requisites, particularly in mathematics. Also, she did not have a good understanding of the work expectations in college courses. In addition, since her parents had to work long hours, her many responsibilities at home made the first year very challenging. The siblings had one car between all of them so Student 6 had to often leave class in the middle of a lecture to pick up or drop off one of her siblings. At the end of the first year, her struggles in some of the courses particularly in mathematics made her contemplate dropping out. But she took a summer class in Pre-calculus and worked very hard on it. Her good performance in that class and the support she received from a counselor in college gave her the confidence to continue. Also, she took a very mature decision of spreading the course load over five years instead of trying to graduate in four. She completed three Co-op/intern assignments, the first one at DTE energy and the other two with Magna International, a tier one automotive supplier. In the first one, most of the work was clerical in nature. But in Magna she worked on active aerodynamics systems both in the software as well as hardware integration. She has been hired by General Motors for their very prestigious Track program which grooms the future leaders of the company. In this program she will be spending four to five 6-month long assignments in different parts of the company before being permanently placed within a particular group. Her family is ecstatic over the success of the first college graduate in the family. Her sister is now working towards a degree in Mechanical Engineering.

Student 8

Student 8's parents emigrated from the Caribbean. Student 8 is the younger of two siblings and was born in New York city where his parents had first settled. The family moved to Florida when he was five but he still considers himself a New Yorker, at least in part. His father works in the technology sector; he has a networking system business. Music has had a lot of influence on Student 8's family. Both his parents are accomplished musicians and his older brother works as a DJ. Student 8 was involved in band and other musical clubs in high school. Also, he is an avid soccer player. In middle and high school, he was in the International Baccalaureate program. Originally, he was more interested in sports and music but the IB program and his academic success in it inspired him to look into a technology focused career. His family's involvement in the technology space exposed him early into this world. He applied to Detroit Mercy primarily because it was a free application through the common application process but after looking into the program more and after talking to a student ambassador on phone and the chair of ME department he got seriously interested. In the end, the financial package that included the S-STEM grant money helped make up his mind. He had his share of doubts in his first year here.

Like many freshmen he was interested in a variety of things and got involved in many groups. After some time, he realized that he had to learn how to manage his time better. And was able to focus more on the academic needs. He is still involved in music and intramural soccer. He was unable to secure an internship/co-op after his first year but closer to his second summer he went to a seminar presentation on campus by an alumnus who worked for Veoneer, a company that specializes in software, hardware and systems for occupant protection, advanced driving assistance systems, and collaborative and automated driving. A simple after-the-talk conversation with the alumnus led to an interview and an offer for internship within a week. Since that first internship Student 8 has worked with Veoneer every summer and now continues to work part-time during the regular semester as well. He feels that the software focused hands-on work he was able to do at Veoneer makes his experience in this program so much more valuable than some of his peers from high school who went to other programs that did not get them exposed to internships or co-ops. He has a very busy schedule between his part-time work and classes but he has been able to finish a minor in Biomedical Design along with the degree in Robotics and Mechatronics Systems engineering. He is very interested in working on prosthetics design sometime in the future. At the moment, when he has a few more months to graduate, he has three firm offers for full-time jobs and five more in the works. Apart from the Veoneer offer he also has an offer for a Ford College Graduate (FCG) position at Ford. The FCG program is an elite track within Ford for new hires. During his early years at this school Student 8 worked in the Alumni relations office. That experience, he feels, gave him great expertise in dealing with professionals and allowed him to improve his all-round inter-personal skills. Student 8 has also been a student ambassador for the college. In that role he visits high schools and meets with prospective students to talk about the engineering programs at this university and this kind of interaction has been super successful at recruiting students to various programs at the university. Student 8 is looking forward to graduating in May 2022 and starting the next phase of his engineering career. He had multiple job offers and, in the end, decided to accept the offer from Ford in their Ford college graduate (FCG) program.

Student 5

Student 5 grew up in Canton, a suburb of Detroit. Student 5's mother works in the healthcare field as a respiratory therapist and her father is a fire fighter. Both parents have bachelor's degrees. She has two younger sisters one of whom is finishing nursing school and the youngest is graduating from high school. A person of influence in her career choice was her grandfather who was an engineer working for General Motors and provided for a large family. Student 5 and several of her cousins have been inspired by his career and are pursuing engineering. During her early years in school, she had Math anxiety and would cry in Math classes but Math turned into her favorite subject in high school. This happened through a combination of things, her teachers helped by working with her through problems when she got stuck and frustrated, also in middle school she scored pretty high in some standardized tests and got placed in advanced math classes. These helped build her confidence in Math. Student 5 was a cross-country runner throughout high school and college. She got admitted to several prestigious state schools. One offered her full-tuition benefit and once she received that offer, she and her family decided that she would like to go somewhere where she would get a full ride. Then she ran into the assistant cross-country coach from Detroit Mercy at a gym. That interaction led her to find out that our school not only had a cross-country program but also a thriving engineering program with co-op requirements. She knew the value of the co-op program because her grandfather went to GMI

(Kettering U.) which also is a mandatory co-op school. She walked in without a clear idea of what major she wanted but the scholarship requirement made the decision for her. Fairly early on she was able to make friends with other students in the major as well as liked the people in her classes. She enjoyed most of the classes in the freshmen year as she was learning all new things. Through family connections, she was able to secure her first co-op at Schuler, a company that makes hydroformed parts. They were getting ready for an audit so she helped them with their Quality documentation. It was a very busy co-op experience and she ended up learning Minitab as part of the process. Next year she interviewed a Fanuc Robotics and was quickly hired once an engineer noticed that she knew Minitab. At Fanuc she worked on robots that are used for painting. The following year she worked at Ford in their division that worked on Driver Assistive Technologies. This third co-op experience she feels was the most exciting and fulfilling. During covid her fourth internship was cut short from 12 weeks to 8 weeks. She worked as the Design and Release Engineer for Sync with Ford. She also completed a fifth year Master's degree at our school. She is currently working for Ford in its Ford College Graduate (FCG) program. She graduated with a Gpa of 4.0 both for her undergraduate and graduate degrees and wants to pursue a Ph.D. degree not too far in the future. She has been training since graduation and ran the Boston Marathon this year.

Student 12

Student 12 was born and raised in the suburbs of Sacramento, CA. Her father works in the furniture business and her mother works for the state government. She does not have anyone in the family with any connection to engineering. She has two younger brothers. Her first encounter with engineering was through a C++ programming class that she took in middle school and thoroughly enjoyed. In high school she participated in a MoBot Robotics competition that is very popular among high school Students in California. She was team captain for three out of the four years in high school. This stint got her very interested in Robotics engineering as a possible major. She got recruited by a small liberal arts school in North Carolina for her softball skills. She spent two years playing softball and going to this school. After two years she searched for a suitable engineering program and found us. She visited, applied and was welcomed as a transfer Student. Because of her unique history, the first two years of her college life was spent taking a lot of liberal arts classes and no science or engineering classes. When she came to our program, she had at least thirty more liberal arts credits than what was needed for engineering, so she ended up taking only engineering classes. She feels that this gave her a unique perspective and maturity since she had done all the right-brain related content first before delving deep into the left-brain topics. This compartmentalization, she feels, gave her a sense of purpose before she delved into deeply technical topics. Also, she has many more liberal arts courses under her belt than any engineering Student would. She sees that as a positive thing because of the maturity and broad view that this experience has given her. Student 12 has a very outgoing personality and a unique life story that, she feels, has helped her quite a bit during the interviews for co-op positions. Within a semester of joining us she interviewed for and secured her first co-op at Fanuc Robotics. She absolutely loved the experience where she worked on an assembly robot cell, doing software simulation, system integration and validation, and finalizing the robot's task by working both with hardware and software. Her second internship was with General Motors where she tested the Drive-by-Wire Systems. GM offered her a full-time position after

the co-op within its Track program which is a prestigious program for college graduates that takes her through 4-5 rotations through different parts of the company before finally getting placement in any particular group. She has a clear plan with what she will be doing in different rotations. She loves the fact that this interdisciplinary major has given her the opportunity to do systems integration where both mechanical and electrical aspects have to be dealt with deftness. She feels that her training puts her in a great position to be able to do this. Because of her outgoing personality and a need for human connection while still doing technical work, managerial position is something that could be in her future.

Student 19

Student 19 is a new Student at the university. He started in Fall 2021 and will only be supported through this grant for one year. He has an interesting background. He already has a Bachelor's degree from University of Nebraska at Lincoln. His degree is in Economics and Digital Advertising. He has worked in the field for almost two years. His parents are IT professionals and he has been seeking a career in a field that brings together hardware and software into technological solutions. He was not satisfied with his first degree and while working full-time decided to pursue a career in Robotics. His online search led to our program and that led to his starting freshmen year in college one more time. He is excited with all the challenging classes such as Calculus and Physics. He is also looking forward to the co-op opportunities and getting hands-on engineering experience at the workplace.

Student 7

Student 7 grew up in the city of Detroit and is the youngest of five siblings. His three sisters finished high school. Two of them work in cosmetology and the third works for the state. His brother did not finish high school. None of his parents went to college. So, he is the first one in the family who attended and finished college. He went to Renaissance high school in Detroit. He loved Science and Math in high school, took a Robotics elective and was part of the Chess club. He did not receive any guidance or help during college applications and applied only to a handful of local schools and he feels he did not know a whole lot about colleges and college applications. A mentoring program that he was part of brought him to the campus of Detroit Mercy where he got a chance to meet the University President and sit in some classes. During that trip he decided to go to school here. He did not seek much help from the very busy counselors and got little as a result. He was pleasantly surprised that our school had a Robotics major because he was really interested in Robotics and that played a part in his deciding to pick the major and college. Student 7 is very shy and had a difficult time asking for help. He feels the small class size and small school atmosphere helped him a lot because a lot of times faculty would approach him and ask him if things were Ok and that encouraged him to ask for help. He also feels that he felt grossly unprepared for college work coming from high school. He was in the Trio upward bound program at the school and through a contact in the program he was able to secure his first co-op in DTE and did three more co-ops there. He worked in the plant, customer services and service center at DTE and was exposed to a variety of different aspects of the power generation company. He also feels that in his early attempts for full-time positions he had a tough time with potential employers since a lot of potential employers did not know much about

the RMSE major. But lately, he has been able to articulate it better. He found full-time employment with General Motors as a Controls Engineer.

Student 2

Student 2 was born in Charlotte, NC to parents who were undocumented immigrants. He has two brothers, one older and one younger. When he was fairly young his father was deported to Mexico. At his age of 10 his parents decided to move the rest of the family back to Mexico. He and his brothers spent the next three years in Mexico where they had a hard time in school because of cultural differences, poor language skills in Spanish and lack of enough financial resources. After spending three years in Mexico the three siblings were sent back to the US by the parents with the hope that they had a chance of having a better life in the US. They spent two years in rural Tennessee with an aunt. Student 2 went to 8th and 9th grade there and experienced overt and covert racism from his schoolmates in this predominately white community. After two years the three brothers moved to Detroit to live with a different aunt. In Detroit, he attended Christo Ray High school, a Catholic high school with a very diverse Student population. Student 2 felt much more at home here and joined several extra-academic programs such as First Robotics club and another program where high school Students had to work for a day every week in a company. Student 2 got to work in manufacturing at General Motors. These two experiences inspired him to pursue engineering. He struggled with adjustment to college expectations throughout the first two years in college. He feels at that time he did not get exposed to enough courses in high school that would have prepared him for college. That is why he had to take many prerequisite courses particularly in the first year of college. Also, throughout his college career he says he struggled with time management and procrastination. The RMSE program has workload that is somewhat higher than other typical engineering programs. Due to all these reasons, he took five years to graduate. For his first internship/co-op he worked at Detroit Energy. He did not like this experience because the work was non-engineering in nature. In the next two co-op assignments he worked at General Motors manufacturing and picked up a variety of skills in welding controls, PLC logic programming and other areas of controls and software. GM offered him a full-time position and he started in their prestigious Track program after graduation; in that program he will be rotating through several six-month long assignments before getting fully integrated into a particular department. He has picked many of his assignments at assembly plants and believes that he has been learning a lot both in the area of engineering skills as well as people-skills. He hopes to continue to work in the area of manufacturing and controls. Although his father has been able to come back to the US and stay with the sons, his mother passed away while they were working through the paperwork to get her back to the US legally. Student 2 remains the only college graduate in his immediate family as his siblings both chose to work in different trades after high school. He is very proud of his achievements as is his family.

Student 3

Student 3 was born in Chicago Ridge, Illinois. He has an older brother and a younger brother and a sister. His parents wanted to go to college and had started but couldn't continue for financial reasons. His mother is a grocery store manager and his father also worked in the same field but at the time of his admission he had taken leave work due to an injury at the work place. So there

was significant financial pressure on the family. His older brother did not go to college but had joined the army and at the time of the interview his sister had started college and younger brother was in high school. He went to the local public school where AP calculus was his favorite class. He also enjoyed the Science classes. Prior to his senior year he did not have a clear idea of what he wanted to study in college. In his senior year he started considering engineering. He was initially interested in Mechanical Engineering and then got interested in Electrical Engineering. His CAD instructor in high school brought the concept of Mechatronics to his attention. Upon searching for programs in the area of Mechatronics and Robotics he couldn't find too many and the program at Detroit Mercy was one that stood out. He was particularly interested in Detroit Mercy because of the fiver year master's option. In making the final decision the S-STEM scholarship made this program extra attractive and that was the reason he decided to come to school here. His time at Detroit Mercy in the Freshmen year was challenging. At that time, he had no friends and family who lived close by. He felt very lonely during this time. He was not planning to go out of state but slowly adjusted living in Michigan. He became more social, and made lot of friends in that first year as well as formed good study habits. He feels it was a big change but a very positive change for him. No matter how hard or difficult it got, dropping out never crossed his mind. He feels that his high school education though not the best, but prepared him well. He also feels that he was able to use the resources in his high school well. In college, he was fortunate to have formed a very close group of friends and those friendships are still going strong. This allowed him to form study groups and led to development of good study habits. Student 3 particularly appreciated having three mandatory co-ops as a requirement for graduation at Detroit Mercy. His first co-op was at an ethernet cabling company in Illinois, close to his home. He worked as a lab-testing intern. Although he feels that the work was not technically intense, he learned many other workplace skills such as professionalism, time management, teamwork, etc. His second co-op was in a switching company, an automotive supplier. He learned to do a lot of testing, report writing, etc. The third co-op was in the cyber-security unit of Fiat Chrysler (FCA). His prior internships helped him secure his third co-op. Despite the heavy workload in all the college classes he was able to finish his undergraduate requirements in four years and continued for a fifth year to finish a Master's degree. During the fifth year he worked full-time while taking classes. His work was on-line and so were the classes during the fifth year due to the Covid pandemic. This made handling both the work and taking classes somewhat easier. He is very happy to be working in the Cyber Security area.

He is particularly cognizant of his unique position in the family. His grandparents came to the US from Mexico in search of a better life and his grandfather worked as a factory worker all his life. His parents grew up in near-poverty situations in difficult neighborhoods, and could not go to college for lack of financial resources. He is the first person in his family who finished college and has a very good and well-paying job in his profession. He understands that the trajectory of his family could be altered significantly for the better because of his success and it will also determine the future of the next generation. He is particularly thankful to Detroit Mercy and this scholarship program for making it all possible.

6. Conclusion

The S-STEM grant period is going to end in August 2022. The stories of individual Students' journeys provide a glimpse of how the scholarship impacted the career of Students who were supported through this grant. Apart from the individual stories there are a few characteristics that have become clear. The curriculum of RMSE is a tough curriculum and many Students came to the freshmen class who felt they were not well prepared for the program. The program is tough and many Students are taking five years or more to finish the four-year curriculum. As per the original plan each Student was supposed to have been supported for only four years. But in reality, that requirement had to be set aside in many cases to make sure that the Students were supported all the way to graduation. A strict adherence to the initial requirement would have jeopardized progress of needy Students. Majority of the Students supported through this grant were first-generation college Students and they faced additional challenges for lack of awareness of many rules and practices of higher education as well as for not being able to anticipate the many challenges. Mandatory co-op /internship is an extremely critical component of this program. For every Student in the program the paid co-op assignments served as a vital launching pad for their career after graduation. Engineering work experiences they received through the three required co-ops and the connections they made during the assignments proved to be invaluable. Incidentally, all the Students who already graduated or are scheduled to graduate in 2022 were hired by one of the big-three automotive companies. We are really proud of this outcome. Those who will still be in the program until the following year are making good progress towards graduation.

7. References

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