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BOARD # 283: NSF RET: Empowering STEM Educators and Revitalizing Manufacturing in the U.S. Midwest

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Dr. Sarder is a professor & director of the School of Engineering at Bowling Green State University (BGSU). Prior to joining BGSU, he worked at the U.S. Air Force Academy as a distinguished research fellow. He served as an associate professor, and graduate director of the logistics, trade, and transportation program at the University of Southern Mississippi (USM). Dr. Sarder has a record of excellence in research, teaching, and services as evidenced by the number of funded grants, list of publications, outstanding teaching evaluations, and professional services in the national and international arena. Dr. Sarder spent more than 15 years in administration as a school director, department chair, graduate director, program coordinator, and assistant director of a research center. During his academic tenure, he developed a school of engineering, a school of aviation, two new engineering programs, a graduate logistics transportation program, and two university centers. Dr. Sarder authored 5 books and 7 book chapters. Two of his textbooks including Fundamentals of Economics for Applied Engineering (2nd edition) with CRC Press and Logistics Transportation Systems with Elsevier are being used in many universities nationally and internationally. Dr. Sarder published more than 100 scholarly articles predominantly on logistics and supply chain domains. He served as a PI and Co-PI on more than 30 grants ($5+ million) funded by several agencies including the US Department of Transportation, the US Department of Commerce, the US Department of Defense, and the National Science Foundation. He received numerous awards in research, teaching, and professional services. Apart from academic pursuits, he is deeply involved in institutional and professional society activities. Dr. Sarder is actively engaged with the AABI and ABET. He serves or has served on the editorial board for several journals including Transportation Research Records, Complexity, and Journal of Enterprise Transformation. He also served as the editor-in-chief of the International Journal of Logistics Transportation Research. He founded the logistics & supply chain division within the Institute of Industrial & Systems Engineers (IISE) and served as the founding president of that division. He also served as Technical Vice President of IISE for three terms. Currently, Dr. Sarder is leading a student leadership board (SLB) and chairing the Future Faculty Fellows (3F) programs at IISE. He served on the College Industry Council on Material Handling Education (CICMHE) board, the academic committee of the Association of Operations Management (APICS), the Transformation Team on the American Society of Engineering Education (ASEE), the Research Committee of Intermodal Freight Transport committee, Freight Transportation Planning and Logistics committee of Transportation Research Board (TRB) among others. Dr. Sarder chaired the Industrial & Systems Engineering Annual Conference in 2016 and 2017, and the Engineering Lean Six Sigma Conference (ELSS) in 2013.

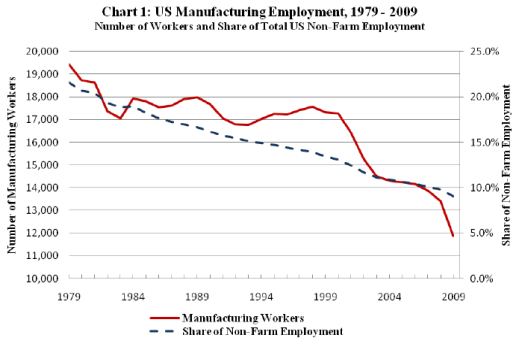
NSF RET: Empowering STEM Educators and Revitalizing Manufacturing in the U.S. Midwest

Abstract

The National Science Foundation (NSF) award (2206952) establishes a new Research Experiences for Teachers (RET) site, enhancing their knowledge and skills in advanced manufacturing/robotics at Bowling Green State University (BGSU). The primary objective of this project is to play a transformational role in preparing future leaders in advanced manufacturing by instilling advanced manufacturing/robotics research experience within STEM educators through six-week summer workshops dedicated to hands-on research projects/experiences. In these workshops, participants engaged with highly qualified researchers using cutting edge robotics technology and augmented by industry access. The research projects focused on contemporary advanced manufacturing topics including modern sensors and actuators, advanced robot programming, CNC programming, CAD/CAM, 3D printing, and e-factory. At the end, participating educators translated their research experiences and knowledge into classroom practice. As part of this research experience, participating educators developed working robots/models, instructional modules, and course materials that they used in their classrooms and shared with other educators at their institutions. The project cements the partnership among BGSU, local high schools, and community colleges to address the common need of producing STEM graduates in advanced manufacturing area. BGSU RET site provided research experience to 28 regional high school and community college educators during 2023-2024. During the 6-week summer workshops, these 28 educators conducted advanced manufacturing research at BGSU eFactory lab and developed curriculum modules for their students. After completion of the summer workshop, many of these educators implemented their curriculum modules at their respective institutions. They will continue to implement these modules in the future and create a sustained wave of awareness among future students in the U.S. manufacturing heartland.

1.0 Introduction

1.1 Project Need and Justification: During the eighties and late nineties, many US manufacturing companies mass outsourced their operations to overseas and experienced a significant job loss. Some experts argue that outsourcing takes up the lower-level jobs and that allows Americans do perform the higher value jobs [1-3]. Nevertheless, that argument does not address the negative impact it had on the Americans especially; US Midwest residents who were laid off and did not immediately find new employment. Outsourcing seems be losing luster in the US as the majority (around 70%) of industry seems to have had a negative experience with outsourcing, according to a survey of 25 large organizations, with a combined $50 billion in outsourcing contracts [4-6]. According to Reshoring Initiatives, more than 237 U.S. companies brought their operations back home and created significant manufacturing jobs. When reshoring, many companies are being located in areas where manufacturing and logistics infrastructures are in place. For instance, Ohio and Michigan rank top ten in attracting reshored companies. This phenomenon will create more manufacturing job opportunities in the region. The only caveat is that these jobs are not traditional manufacturing jobs rather advanced manufacturing/robotics jobs.



Skill-biased technical shift has been a pervasive feature of today's American economy. Technology-skill complementarity has also been widespread over the past century with new technologies from those associated with internet and computer revolution to the robotics revolution, which as of today has been primarily shaping the future of the world manufacturing industry. However, according to Ohio Manufacturing Association 2015 report, there is more than 670,000 traditional manufacturing jobs in Ohio, ranking the third in manufacturing employment nationally, and providing more than $52 billion in products to 216 countries and territories [7, 8]. The manufacturing is undergoing rapid changes due to the demands of product variety, and therefore factories are demanded to become smarter and more efficient. This transformation is defining the factory of future, which is also known in US by advanced manufacturing [8], and it will require labors to come to terms with complex processes, machines and components.

The U.S. Midwest is known as the heartland of U.S. manufacturing since last century. Today's manufacturing is quite different from traditional manufacturing and it relies heavily on automated and integrated systems. Traditional manufacturing skills are no match to those advanced manufacturing/robotics skills. This RET project provides a platform for researchers and educators to investigate new research opportunities in engineering and technology to fill the existing skills gap in advanced manufacturing. The unique significance of this project is to instill robotics research experience within STEM educators through six-week summer research projects at the state-of-the-art robotics research lab (e-Factory) at BGSU under the supervision of robotics faculty mentors. This unique hands-on research experience combined with local industry collaboration prepared future STEM teachers, who will be able to interject research experience in a classroom learning and tie that with the real-world implementations.

1.2 The goal of this RET program- Our program is built around a visionary goal: to provide educators with advanced knowledge and hands-on experience in advanced manufacturing and robotics. The RET program is redefining STEM education by incorporating cutting-edge research into high school and community college classes, thereby influencing the future of our students and the industry.

2.0 Empowering Educators and Revitalizing Manufacturing

This initiative brought together 28 educators from various high schools and community colleges. Overall, we estimate that we have reached over 10,000 students throughout Northwest Ohio. Our purpose bridge the gap between classroom learning and industry expectations by giving educators unique research opportunities. This prepares them to provide creative, practical curricula to their students, thereby meeting the regional demand for competent workers in advanced manufacturing. This year, BGSU also organized four industry trips to provide educators with hands-on industry exposure. Following picture captures 2024 K-14 participants with BGSU PI team.

2024 K-14 Participants are primarily from Northwest Ohio region with a couple of exceptions. These participants were very active in research activities under the supervision of BGSU PI team. Following figures show the locations of these participants' home institutions and their research engagement at the BGSU labs.

Figure 2: 2024 Participant Activities

Experience of industry tours:

This year's RET program included four industry tours, allowing participants to gain direct experience with manufacturing operations and then share their findings with students. The companies are Kauffman Engineered Systems, Robotic Technical Support Services (RTSS), NSG Glass Manufacturing and First Solar.

- **Kauffman Engineered Systems:** Educators observed custom automation solutions, focusing on packaging machinery, robotic palletizing, and conveyor systems.
- **NSG Glass Manufacturing:** Participants looked into new glass production techniques and technologies used in the architectural, automotive, and technical glass markets.
- **Robotic Technical Support Services (RTSS):** The tour demonstrated advanced robotic systems, taught pendants, and LIDAR technologies, emphasizing their use in current production.
- **First Solar:** Participants learnt about the sustainable fabrication of thin-film solar panels using CdTe technology and discussed future collaborations in K-12 STEM education.

3.0 Transforming STEM Education

The RET program brought together educators from a variety of fields, including mathematics, computer science, physics, engineering, robotics, and electrical engineering. Each had unique but aligned goals. Olivia, a mathematics teacher, developed a robotic car incorporating algebra to make math more engaging for her students. Mike focused on small-scale robotic cars, exploring autonomous vehicle control. Bader worked on a smart house project aimed at simplifying daily life. The shared goal of their endeavours was to make lessons more entertaining for pupils so that they could study science and engineering without fear. During the six-week program, participants acquired practical expertise with modern sensors, 3D printing, Arduino, advanced

robot programming, CNC programming, CAD, and e-factory systems, preparing them to inspire and educate their students in novel ways.

As we wrap up this year's RET program, the adventure does not end here. The program's knowledge and experiences will continue to spread throughout schools, influencing the future generation of students. In the future, we expect our STEM educational activities to evolve and improve even more. To satisfy the industry's ever-changing expectations, we will continue to prioritize innovation, curriculum improvement, and collaboration expansion. We are thrilled about the future and the ongoing effect of our program as we collaborate to promote improvement and inspire the next generation of STEM leaders.

4.0 Program Evaluation

Basic components of the program evaluation were two-fold. The first component tracks the number of educators who complete the program throughout the project years. Second component tracks the satisfaction of the program participants vis-à-vis their reasons to partake and expectations on translating their growth in knowledge and experience into improved classroom materials and pedagogy. This second component used a pre-program and post-program questionnaire structure. The survey was designed in a collaborative effort by the PI team and the external evaluator.

In the second year of the program, in addition to the surveys and descriptive analysis of the participants, a brief interview was added to the external evaluation effort to receive feedback and explore the reactions to specific improvements in comparison to the previous year (i.e., an increase in industry tours from one to four). Below in Table 1, percentage of responses in agreement categories is provided (those who responded with positive views). Shown numbers exclude neutral responses. Three numbers are of significant note among Part 1 responses. First, 80% of the participants indicated that they would recommend the program, representing ~7% improvement in the participant perceptions. Considering that this is the second offering of the program, the areas for which significant improvements were observed were: organization of the program and its perceived benefits in increased scientific knowledge and research skills.

Table 1. Post-Program Survey Results

Part I. Organizational Quality & Overall Experience	**Agreement 2023 cohort**	**Agreement 2024 cohort**	**Comments**
1. This Research Experience for Teachers program was well organized as a whole.	**26.66%**	**62%**	Significant improvement observed.
2. BGSU was well suited to host this program.	86.66%	86%	Stable performance.
3.This program helped me to improve my research skills.	40.00%	88%	Significant improvement observed.
4. This program helped me to increase my general scientific knowledge.	60.00%	74%	Improvement observed.
5. I would recommend this program to others.	**73.33%**	**80%**	Improvement observed.

5.0 Overall Conclusion

In view of the pre-program and post-program survey data analyses, it can be concluded that educator participants of the program increased their knowledge and research experiences at very high-quality research facilities and under expert guidance. Overall, 70% participants concluded that they would recommend the program, signaling its value.

Acknowledgement

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