

## **Building Capacity to Identify and Address the Needs and Challenges of STEM Education Majors**

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This article is based on work supported by the U.S. National Science Foundation (NSF) *21-578 Robert Noyce Teacher Scholarship Program* under Grant No. 2150954. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF.

## **Executive Summary and Accomplishments:**

This Noyce Capacity Building Grant focused on efforts by Millersville University of Pennsylvania to address the need for secondary Science, Technology, Engineer, and Mathematics (STEM) teachers in Pennsylvania and to strengthen several areas of its secondary STEM teacher certification programs in order to take steps to foster and support the success of secondary STEM-focused prospective teachers who complete program requirements while also simultaneously building the groundwork for a future “Noyce Track 1: Scholarships and Stipends” proposal. Millersville University has a long tradition of producing certified teachers. Despite strong overall student enrollments in several undergraduate STEM secondary education majors, the number of program completers declined ( $\approx 33\%$ ) from 2016-2021. For the duration of this project, 2022-2023, key data was gathered to identify and ensure the success of secondary STEM-focused prospective teachers and to address the two main objectives of the project: (1) Identify and assess STEM education majors’ academic needs and challenges to help them earn their teacher certification and (2) Create a STEM Faculty Advisory Council that would define role(s) for faculty advisors of STEM education majors and an established community structure to address the students’ needs and challenges identified through (1).

The project team met the identified objectives and the following key accomplishments resulted through meeting the proposal’s objectives. **The accomplishments were:** (1) the addition of a fully funded graduate assistant position responsible for assisting with STEM education student and faculty communities and STEM community outreach, (2) an identified and established faculty community who will continue to meet regularly, and (3) the creation of a BSE STEM website that will contain information for BSE STEM students and faculty advisors.

## **Intellectual Merit**

The project team identified barriers, both structural and perceived, that might be keeping undergraduate students who begin as STEM education majors from persisting in their desire to enter the teaching profession. By developing a greater understanding of these barriers and how to address them, this work will make an important contribution to the field. In addition, this project team developed a model for faculty collaboration across the various BSE STEM programs to define and create better support for STEM education students. The knowledge gained through this project will contribute to the broad goals of teacher education at Millersville University.

## **Broader Impacts**

The work from this capacity building project was significant for BSE STEM education majors at Millersville University in that it addressed issues focused on recruitment and retention of BSE STEM education majors as well as implementing efforts to enhance the quality of teacher preparation for STEM education majors. For Millersville University STEM faculty, the results of this project provided greater familiarity with STEM education majors’ academic needs and challenges as well as an action plan to increase faculty collaboration and identification of faculty roles related to STEM education majors. We also were able to identify a mechanism to streamline a communication system between various stakeholders who contribute to STEM education majors’ education and plan to share our model with other universities with similar programs to adapt to meet their needs. The ability to create improved communication efficiency among STEM faculty coupled with effective advisement and community building is essential for increasing the number of STEM education majors at Millersville University and contribute to the total number of STEM educators nationwide. Results of this study helped to identify barriers to

students entering programs of STEM education majors at Millersville University that will provide these students greater support and direction so that Millersville University will contribute to improving the quantity and quality of STEM education major program completers who enter our public schools.

## **Introduction**

Millersville University of Pennsylvania (MU) has a long tradition of producing certified educators. The university was established in 1855 as Pennsylvania's first Normal School to train teachers and 166 years later, it has integrated 21<sup>st</sup> century approaches into teaching and learning in areas of early childhood, middle level, secondary, and special education programs. Despite strong overall student enrollments in several undergraduate Science, Technology, Engineering, and Mathematics (STEM) secondary education majors (i.e., biology, chemistry, earth science, mathematics, physics, and technology and engineering education [TECE]), from here on referred to as STEM education majors, the number of program completers has declined ( $\approx 33\%$ ) in the past five years (from 2016 – 2021). The rationale for this Noyce Capacity Building project was to gather sufficient data to better understand the reason(s) as to why BSE STEM majors were not completing their respective education programs. The goal was to collect key data that would allow the project leaders to identify and ensure the success of secondary STEM-focused prospective teachers. To achieve our goal, we established two main objectives: (1) Identify and assess STEM education majors' academic needs and challenges to help them earn their teacher certification, and (2) Create a STEM Faculty Advisory Council that would define role(s) for faculty advisors of STEM education majors and an established community structure to address the students' needs and challenges identified through the first objective.

### *Context*

Across the nation at the university level, there is a considerable shortage of qualified mathematics and science education teacher candidates enrolled in secondary STEM education programs (AAEE, 2021). These challenges have been documented in newspaper headlines (e.g., Times Editorial Board, 2017) and various state reports (e.g., Pennington McVey & Trinidad, 2019). Teacher shortages predate the pandemic, as there have been mathematics and science teacher shortages since the 1950s (Darling-Hammond, 2010), but the COVID pandemic has only amplified these teacher shortages and “the teacher shortage is more acute in high poverty schools and magnified in subjects like...science and math” (Shahbazi, 2021, p. 1). Furthermore, teacher shortages are a serious concern: recently, nationwide, Sutchter, et al., 2019 “estimated a teacher shortage of approximately 64,000 teachers in the 2015-16 academic year and an annual shortage of 112,000 teachers in 2017-2018” (p. 4). In Pennsylvania, the number of Instructional I Certificates issued across all disciplines has fallen in the past decade, with 21,045 awarded in 2010-2011, 12,182 awarded in 2014-2015, and 6,937 awarded in 2019-2020 (Pennsylvania Department of Education, 2021). Given the current shortage, it is imperative that we retain those undergraduate students who indicate an interest in STEM teacher education.

Millersville University, a public regional university with an undergraduate enrollment of approximately 6,500 students, is one of fourteen institutions that make up the Pennsylvania State System of Higher Education (PASSHE). In the past five years, MU has awarded approximately 235 bachelor's degrees in K-12 education at all levels. Unfortunately, about only 28 of those were secondary STEM education graduates. Moreover, in the past five years the number of program completers in the STEM teacher preparation program at MU has decreased from 33 in 2017 to 22 in 2021 (see Table 1), which is similar to trends observed nationally (AAEE, 2021). Despite the decline in STEM education major program completers, MU's secondary education STEM freshman enrollment has been relatively constant (see Table 1). The data points to potential issues with retention of STEM education majors.

**Table 1**

*Number of Secondary Education STEM Teacher Candidates, Freshman Enrollment, and Program Completers 2016 – 2021 at MU*

	Number of	BSE Biology	BSE Chemistry	BSE Earth Sciences	BSE Mathematics	BSE Physics	BSE TECE*	TOTAL
2016-2017	Candidates Enrolled	16	11	5	60	5	59	156
	Freshman Enrolled	4	4	0	14	2	12	36
	Program Completers	1	2	2	14	1	13	33
2017-2018	Candidates Enrolled	21	5	6	54	5	57	148
	Freshman Enrolled	3	0	2	18	1	11	35
	Program Completers	5	0	0	10	0	13	28
2018-2019	Candidates Enrolled	20	5	7	60	4	67	163
	Freshman Enrolled	1	2	0	20	0	17	40
	Program Completers	3	2	2	6	0	11	22
2019-2020	Candidates Enrolled	28	10	8	61	5	66	178
	Freshman Enrolled	9	3	4	24	2	10	52
	Program Completers	1	1	1	7	2	10	22
2020-2021	Candidates Enrolled	33	8	3	62	4	67	177
	Freshman Enrolled	9	6	1	20	2	17	55
	Program Completers	1	0	0	8	1	12	22

*NOTE: Undergraduates only (not Post Bac)*

*\*TECE: Technology & Engineering Education*

### *Current Infrastructure*

In Fall 2020, 2266 out of 6493 undergraduate students at MU (approximately 35%) pursued degrees in STEM fields. Millersville University has strong STEM academic and professional programs. The Chemistry, Physics, Mathematics, Earth Science, and Biology Departments have ten, seven, sixteen, ten, and nineteen full-time faculty respectively with expertise in their fields, which provide multiple skills and knowledge that can help future STEM educators succeed in their careers. The collaboration between STEM faculty has been consistently a strength of MU programs. The STEM faculty often work together on different activities such as the Science Olympiad, PASSHE STEM Undergraduate Research Conference, the Annual Glenna Hazeltine

Women in Mathematics, Science, and Technology Conference, and a number of funded research endeavors. Moreover, the small number of STEM education majors, 177 out of 2,266 undergraduate STEM majors, suggested that MU has the capacity for fostering additional STEM education majors within its current student population. The required resources and knowledge were available at MU for STEM future educators to succeed, yet there was a critical need to identify and assess the needs and challenges of the STEM education majors to help them succeed.

### *All-Hands Forum*

To identify and assess STEM education majors' academic needs and challenges, we created a STEM education faculty collaborative community (i.e., faculty advisory council) consisting of 10 members from science and education faculty as well as representatives from the library and academic advisement that would establish faculty roles and contributions to the success of STEM education majors. The project team along with the faculty collaborators participated in a two-day forum, off campus, where conversations centered around improving student engagement, connection and community building. The discussion also addressed how to best identify academic needs and challenges facing STEM education majors to improve their engagement, retention, and program completion. Prior to the forum, attendees received background information on STEM education majors' retention, persistence, and degree completion. In addition, data were shared from faculty and student surveys. Faculty (from the College of Science and Technology as well as from the College of Education and Human Services) were surveyed about how they currently support STEM education majors (42.3% response rate [47/111]) and STEM education majors were surveyed to garner a sense of their needs and challenges that if met, would improve their academic experiences at MU (35.7% response rate [66/185]).

Four working groups were formed during the *All-Hands Forum* retreat centered around: (1) BSE program status (e.g., field placements [e.g., scheduling, are they in secondary classrooms of their major], program structure, certification changes); (2) student advisement (e.g. role of advisor/co-advisor, department policies for BSE advising, curriculum guide availability, accuracy); (3) BSE student needs (e.g., community building, academic support, mentoring, program identity, career awareness); and (4) the university-wide perspective and faculty needs (e.g., communication structure between College of Education and BSE science/mathematics faculty and the structure for BSE advisor role). By the end of the two-day *All-Hands Forum*, the four working groups identified data (e.g., persistence rate, 4–6-year graduation rates and statewide university data) and other relevant information (e.g., current Pennsylvania Department of Education certification requirements, STEM major curriculum guides, and STEM major advisee assignments) needed to address their posed problem. All working groups created a list of data sources and designed potential interview questions for students and faculty as well as student focus group protocols that concentrated on barriers, perceived or real, that students face while pursuing their STEM education major.

### **Data Sources and Data Collection**

Following the *All-Hands Forum*, in late fall, 100% of the 33 BSE STEM students who were one semester away from student teaching and 13 BSE STEM students who had completed their Educational Foundation Bloc completed a Qualtrics survey. The survey questions focused on collecting information about their experiences in their specific BSE STEM program and

gathering feedback on the effectiveness of courses offered in their respective program. Science and education courses were examined for all participants, as were individual experiences with field placement opportunities. Over 40 students in total were surveyed regarding the academic program they were enrolled, and four of those students indicated a willingness to participate in a one-hour focus group. The purpose of this focus group was to engage with students in a deeper dialogue of their experiences in the BSE program to determine what was being done well and areas for improvement. The four BSE students, all with different science major backgrounds, anonymously participated in a 40-minute focus group interview, which was recorded and transcribed. See Appendix A, B, and C for the Qualtrics survey questions and the semi-structured protocol for the focus group interview. Data were collected to address the objectives identified above and the project management team used open-ended and descriptive coding (Saldana, 2016) to identify relevant themes in the data. The interviews and resulting themes were shared with the working groups.

Each working group met to review the data and the preliminary data analysis. Findings were shared with the entire group at Debrief Meeting #1 in February 2023. At the conclusion of this meeting, several action items were identified, and the leadership team met with the Deans of the College of Science and Technology and the College of Education and Human Services to share the findings from the data. Below are the significant Action Items from the student surveys and focus group data.

### **Action Items**

- 1) **Web Portal for STEM BSE Focused Information:** At MU, each department offering a STEM BSE degree maintains information on their respective websites related to curriculum and academic pathway documents. Through the conversations at the *All-Hands Forum* meeting and the focused discussions of working groups, it was determined that STEM BSE majors would greatly benefit from a single portal where they would be able to access information on their curricular requirements, academic pathways, required clearances, tests, and important due dates among other information. As a result, a prototype was created that focused on a one-stop resource center for the current STEM BSE majors. In addition to curricular and advisement information, the resource center would include information on events, related organizations and opportunities for further engagement for the STEM BSE majors. Additionally, this resource center would help faculty advisers to be able to better guide their advisees with the most up to date information. As part of this effort, departments offering STEM BSE degrees will be updating the information on curricular and pathway documentation to be streamlined with the STEM BSE resource center. With support from the Dean of the College of Science and Technology, the development of the prototype into a functioning resource center will greatly aid students to successfully complete their degree programs. Furthermore, the resource center will play an integral role in sharing information that would help to build the STEM BSE community.
- 2) **BSE STEM Advising:** Student surveys and focus groups showed that multiple students and their content academic advisors were unaware that BSE STEM majors have an education advisor in addition to the academic advisor. Knowing who is their designated education advisor is an integral part of the BSE STEM major's academic journey. The BSE STEM program is complicated as it includes various requirements, clearances, and

assessments. Not knowing who their education advisors are leaves the students feeling lost, unsupported, and unsure about their academic progress. In summary, both advisors play a crucial role in guiding and supporting the students throughout their BSE STEM academic program. To ensure that all students are aware of who their academic advisors are, both the content and the education advisor will be listed in the student online degree audit system. There will be an established rotation process where the student's mandatorily meet with their content and education advisors every semester to discuss their academic progress and obtain the access code needed to register for courses. The second issue regarding academic advising is that some of the content academic advisors were unaware of all BSE STEM requirements for their education program. To address this issue, the BSE STEM content advisors will be centralized within each department. Centralizing the advising process and assigning a few faculty members per department as content advisors will provide students with a more efficient, consistent, and accurate advising experience. Even if a student enrolls as a non-BSE STEM major, once they declare themselves as a BSE STEM major, the chair of their respective department will re-assign the student to one of the designated content advisors. Taking steps to ensure that all BSE STEM majors are correctly advised will help to improve their overall academic experience and increase their chances of success.

- 3) **Building a Community on Campus to Support Students Majoring in Secondary Teaching in STEM Subjects:** Millersville University struggles to retain students who major in Secondary Teaching in STEM subjects (BSE STEM) as evidenced by the yearly difference in the number of freshmen BSE majors and the number of graduating students (see Table 1). The NOYCE Capacity building grant identified the lack of a campus community to support BSE STEM majors as a contributing factor to students' failure to persist in the major. Overall BSE STEM major enrollment numbers are small compared to BS and BA majors in each of the STEM disciplines and this can lead to feelings of isolation. To address this deficit in community support, the NOYCE Capacity building grant identified the need for additional personnel. The Deans of the College of Science & Technology and the College of Education & Human Services worked together to create a fully funded graduate assistant position responsible for STEM Community Outreach (e.g., leverage and build on existing connections with local schools/community). The goal is to get BSE STEM majors involved in STEM education starting on their first day on campus via involvement in MU sponsored STEM education teaching opportunities on campus and in the community (e.g., local libraries, School District of Lancaster, science night for PTA, tutoring after school, science fair at MU, lead NSTA student organization) organized and facilitated by the newly created STEM Community Outreach graduate assistant position.
- 4) **Issues of Access and Equity:** Through surveys and focus group discussions, BSE STEM majors identified barriers to completing their degree/certification requirements. Some of these barriers are especially difficult to overcome for students who struggle financially and are low SES. Being an education major includes costs that students in other majors are not burdened with. These hidden costs include certification testing, field placement clearances, professional wardrobes, and transportation. As part of the work of the Noyce Capacity Building grant, a list of those costs was developed. Over the course of a 4-year



program, a STEM BSE major spends an additional \$4,000 in order to complete their teacher certification program. These costs are not eligible costs that can be covered by financial aid or student loans. One goal is to increase awareness of these costs by providing a breakdown of the list to potential and current STEM BSE students through the Admissions office and the College of Education and Human Services. Another goal is to examine cost saving measures that can be implemented (e.g., having fingerprint services on campus, professional wardrobe closet, placements with consideration for limited transportation).

- 5) **Future Faculty Collaboration:** The Noyce Capacity Building grant allowed 10 faculty collaborators from the College of Education and Human Services, College of Science and Technology, and University College (Academic Advisement and Library) along with the authors to meet for a retreat (All Hands Forum). During the retreat, the collaborators opened lines of communication that were dormant or non-existent. Information and concerns were shared and discussed in a face-to-face manner, not in a virtual meeting or email chain. The faculty collaborators strongly believed that maintaining the momentum from the work done through this grant was imperative. With support from the Deans of the Colleges of Education and Human Services and Science and Technology, there is a plan to reconvene the collaborators for a local day-long retreat. The collaborators will discuss updates to goals, action items, information, and assessments related to BSE STEM majors.

## Summary

Action items one through four align to the first objective of the project: Identify and assess STEM education majors' academic needs and challenges to help them earn their teacher certification while the fifth action item aligns to the second objective: Create a STEM Faculty Advisory Council that would define role(s) for faculty advisors of STEM education majors and an established community structure to address the students' needs and challenges identified through the first objective. Through the work of the project leaders, faculty advisory council, and the Deans of the College of Science and Technology and the College of Education and Human Services, the project team met the identified objectives and the following key accomplishments resulted through meeting the proposal's objectives. **The accomplishments were:** (1) the addition of a fully funded graduate assistant position responsible for assisting with STEM education student and faculty communities and STEM community outreach, (2) an identified and established faculty community who will continue to meet regularly, and (3) the creation of a BSE STEM website that will contain information for BSE STEM students and faculty advisors.

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## Appendix A

### EDFN 211/241 Student Survey – Fall 2022

1. What is your major?
  - BSE Bio
  - BSE Chem
  - BSE Earth Science
  - BSE Mathematics
  - BSE Physics
  - BSE TECE
  
2. How would you describe the high school from which you graduated?
  - Urban
  - Suburban
  - Rural
  - Other (e.g., Home schooled, Cyber school)
  
3. Where was your field experience?
  
4. What was the content area(s) of your field experience classroom?
  
5. Were you in a classroom that aligned with your major?

Questions #6 & #7: Likert-scaled items, 5 levels

6. Respond by choosing how much you agree or disagree with the following statements.
  - My field experience was meaningful.
  - I learned a lot during my field experience.
  - Traveling to my field experience site was reasonable.
  - Transportation to the field experience site was challenging.
  - I was aware of course expectations related to my field experience.
  - I felt well-prepared to attend the field experience.
  - I felt well-prepared to perform in my field experience.
  - My field experience was a positive experience.
  - My field experience provided opportunities to work with students.
  - My field experience provided opportunities to interact with teachers.
  - During my field experience, I learned about the challenges and opportunities in schools.
  - My field experience broadened my views of teaching and learning.

7. How has this field experience influenced your decision to be a teacher?

- Greatly increased my interest
- Somewhat increased my interest
- Did not change my interest
- Somewhat decreased my interest
- Greatly decreased my interest

8. Do you intend to continue in your teacher education degree program?

- If no or not sure, request open-ended explanation.
- What has influenced your decision to not continue?

9. What suggestions do you have about your field experience?

10. Are you willing to participate in a 1-hour online focus group towards the end of the semester to discuss your experience?

## Appendix B

### BSE STEM Student Survey – Fall 2022

1. When do you plan to complete your program?

- 2023
- 2024
- Other

2. Identify your major.

- BSE Bio
- BSE Chem
- BSE Earth Science
- BSE Mathematics
- BSE Physics
- BSE TECE

\*Based on question 2, a list of courses is generated based on major selection. STEM education courses were also provided for each question separately, regardless of major.

3. Of the following courses, select up to three that fostered your identity as a Science, Technology, Engineering, and/or Mathematics (STEM) educator.
4. Of the following courses, select up to three that was/were a struggle for you. It may have been a course that made you reconsider being a STEM educator or a course that you did not do as well as you anticipated.
5. Which resources (e.g., tutoring, peer study groups, library, peer mentor) did you utilize to succeed in your courses?
6. During your time at Millersville, did you ever consider changing your BSE major? If yes, what prompted you to consider changing? What experience(s) have you had that have helped you to remain in your STEM major?
7. Are you willing to participate in a one-hour online focus group towards the end of the semester to discuss your experiences in your STEM major at Millersville University?

## Appendix C

### Semi-Structured Focus Group Questions

**Say to the participants:** Thank you for participating in this project. We are interested in documenting your responses to questions around advisement and your degree program.

**Say to the participants:** Do I have permission to record this interview?

#### **EFDN 211/241**

1. Why did you choose to major in BSE STEM Education here at Millersville?
2. How would you describe your BSE degree program so far if you were talking to a friend?
  - a. Would you recommend your degree program to a friend? Why or why not?
  - b. What are some of the strengths of your BSE degree program?
  - c. What is one thing you would change about your degree program?
  - d. What was the best experience you've had in your degree program so far?
3. Tell me about your advising experiences. (e.g., from your major and/or education faculty related to advising...push for whether PT is talking about major/education advisor)
  - a. What are your biggest concerns regarding advisement?
4. How did you learn about your curriculum (plan of study/graduation requirements/4-year plan)?

Some suggested phrases to pose to PTs to draw out more detail:

- Can you talk more about...
- Can you give an example...