BOARD # 349: Cultivating Curiosity: Faculty Insights on Mentoring S-STEM Undergraduate Researchers

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Research Interests: First Year Engineering Student Success (summer bridge programs); Mathematics retention of underrepresented minority students; Role Identity & Persistence (low-income undergraduate students); Conceptual Understanding (mathematical situation models); Hybrid learning (instructional technology); Early Algebra (textbook analysis)

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Dr. Rungun Nathan, Pennsylvania State University, Berks Campus

Rungun Nathan, a professor and founding program chair for the mechanical engineering, joined the faculty at Penn State Berks in 2007 as an assistant professor and was promoted in 2012 to associate professor. He subsequently was promoted to Professor in 2021. He has over 30 combined years of increasing responsibilities in industry and in academia, including at the Centre for Development of Telematics (C-DOT), a telecommunications technology arm of the Indian government, the Indian Institute of Science (IISc.), Bangalore, and Villanova University, PA. Nathan received his BS from the University of Mysore, a postgraduate diploma from the Indian Institute of Science, an MS from Louisiana State University, and a PhD from Drexel University. He worked in electronic packaging in C-DOT and then as a scientific assistant in the robotics laboratory at IISc. in Bangalore, India, and as a postdoc at the University of Pennsylvania in haptics and virtual reality. His research interests are in the areas of brain traumatic injury, unmanned vehicles, particularly flapping flight and Frisbees, mechatronics, robotics, MEMS, virtual reality, and haptics, as well as teaching with technology. He has ongoing research in brain traumatic injury, flapping flight, frisbee flight dynamics, lift in porous material, and wound therapy. He is an active member of APS (DFD), ASEE, ASME, and AGMA, and is a reviewer for several ASME, IEEE, ASEE, and FIE conferences and journals. He is co-editor for ASEE publication Computers in Education. Nathan has been a very active member of both the Mechanics and Mechanical Engineering Divisions of ASEE since 2006. He started as a member at large and then rose to chair the Mechanics Division in 2012–2013. He currently is chair of the Mechanical Engineering Division after starting as member at large in 2017. Nathan also has been an active member of ASEE's Engineering Technology, Computers in Education, Educational Research Methods, Multidisciplinary Engineering, Experimentation and Laboratory-Oriented Studies, and Systems Engineering Divisions. He also serves as a Program Evaluator for EAC and ETAC with ABET.

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Cultivating Curiosity: Faculty Insights on Mentoring *S-STEM* Undergraduate Researchers

Leveraging Innovation and Optimizing Nurturing in STEM (NSF S-STEM #2130022, known locally as LION STEM Scholars) is a program developed to serve low-income undergraduate Engineering students at Penn State Berks, a regional campus of the Pennsylvania State University. As part of the program, scholars participate in a four-year comprehensive multi-tiered mentoring program and cohort experience. The LION STEM curricular program includes Engineering Ahead (a 4-week summer residential math-intensive bridge program prior to entering college), a first semester First-Year Seminar, and a second semester STEM-Persistence Seminar. Co-curricular activities focus on professional communication skills, financial literacy, career readiness, undergraduate research, and community engagement.

The purpose of this paper is to describe the impact that two rounds of accelerator grants from the NSF Research Hub on inter- and intra-institutional partnerships at Virginia Tech University have had on our S-STEM project. These accelerator grants have helped to create *Sprouting Research from Year 1,* in which each LION STEM Scholars (*n=4)* was paired with an engineering faculty member who served as their formal research mentor during their first year of college. What follows are the insights and responses to suggestions from the engineering faculty mentors who worked with the S-STEM undergraduate researchers.

Building Partnerships Across STEM Faculty

Math-intensive summer bridges are among the most successful STEM retention tools utilized in the nation because they curb the attrition that occurs in the first year at a new institution. In addition, success in foundational mathematics courses, which are pre-requisites for entrance to major courses, paves the pathways for success in applied STEM curricula. Thus, mathematics professors and not Science, Technology or Engineering faculty members are typically chosen to run summer bridge programs in STEM. It therefore becomes essential to design, build, and sustain intra- and inter- institutional partnerships for these mathematics faculty members who are systematically trying to support students across a variety of applied majors within STEM.

When Engineering Ahead began, a mathematics faculty member who was exclusively trained to teach first-year students (a prior high-school mathematics teacher who is now a full-time mathematics professor) was chosen to create the summer bridge program. Charged with the learning outcome of preparing students for their college-level first-year Calculus courses, that faculty member initially developed Engineering Ahead to exclusively focus on mathematical pre-Calculus level problem-solving skills. Because students are often not aware of how their high school skills measure up to those required in college, the inaugural Engineering Ahead curriculum also included some metacognitive skills surrounding learning mathematics.

By reviewing research of other summer bridge programs, as well as both formal data collection and anecdotal feedback from Engineering Ahead students, it became obvious that mathematics review and preparation was not the only significant factor that related to increasing retention in engineering. Thus, over the last nine years, Engineering Ahead has worked to build intra- and inter-institutional partnerships to systematically support student success. What started out as a

close daily interaction with a single mathematics faculty member during the summer bridge, now includes cooperative learning under the supervision of peer mentors as well as partnerships that have been built with 20+ faculty members across Physics, Chemistry, Computer Science, and Engineering who present guest lectures and hands-on lab activities.

Engineering Faculty Mentoring

Although great strides have been taken to build partnerships, a missing component of Engineering Ahead was connecting first-year engineering students with engineering faculty. Most first-year engineering students at Penn State Berks are assigned a non-engineering faculty advisor and typically only enroll in one engineering course during their first year (Cornerstone Design). In addition, undergraduate research is vital for enhancing critical thinking skills and boosting STEM persistence (Kuh, 2008; O'Donnell et al., 2015), yet it too was a missing component of Engineering Ahead. Recognizing these gaps, we created *Sprouting Research from Year 1*, which paired pair each of our first year LION STEM Scholars (*n=4)* with an engineering faculty member who served as their formal research mentor during their second semester of college.

Table 1. Characteristics of Cohort 1 S-STEM Scholars and Faculty Participants

Scholar Participants			**Faculty Participants**		
Variables	N	%	Variables	N	%
Pell Eligibility	4	100	Engineering	4	100
Gender			Gender		
Male	4	100	Male	2	50
Ethnicity			Female	2	50
Hispanic	2	50	Appointment		
White	2	50	Tenure	2	50
First-Generation	2	50	Non-Tenure	2	50

Sprouting Research From Year 1

To maintain the cohort and provide extended support services, all students in Engineering Ahead enroll in a 1-credit STEM Persistence Seminar during their second semester. Four (*n=4*) LION STEM Scholars from our first cohort of S-STEM scholars engaged in the first accelerator grant *Sprouting Research from Year 1,* where instead of them attending the STEM Persistence Seminar with the other Engineering Ahead students, they were paired with an engineering faculty member (*n=4*) who was interested in exploring undergraduate research with a first-year student. The program chairs for both engineering degrees on campus (ME & EMET) were two of the faculty members and together took on the responsibilities of creating and orchestrating this project. Over the course of the fifteen-week spring semester, scholars and faculty mentors met on a weekly basis (60 minutes during the original STEM Persistence Seminar timeslot) to expose the scholars to the concepts and activities surrounding research in engineering. During the first meeting, mentors shared with scholars about their individual research interests and the mentors allowed the scholars to decide which students would work with which mentors based on shared interests. Faculty mentors then met bi-weekly with their mentees to discuss and develop individual research interests and on the off weeks met all together as part of a group session about broader research concepts. Group sessions covered included an introduction to research methodologies, how to write research questions and conduct literature reviews, communicating science and

scientific writing, ethics and scientific misconduct, presenting data and best practices for oral & poster presentations. During the last week of the semester, all scholars presented their research questions and literature review in a group setting which led to rich conversations and critiques of the research ideas present in the room.

Faculty Insights on Mentoring First Year Research Students

To gain insights into the motivations and expectations of the faculty mentors, a focus group was conducted at the end of the semester. The transcript of that meeting was analyzed using the Dynamic Systems Model of Role Identity (Kaplan & Garner, 2017). Findings suggest mentors were motivated by the diversity, equity, inclusion and belonging (DEIB) nature of this initiative, a modest financial incentive ($500.00 funded from the accelerator grant), and a desire to build deeper connections with scholars. All the mentors presented to the Engineering Ahead program during the summer but were eager to connect with the S-STEM scholars beyond a one-time presentation. They viewed the program primarily as a teaching opportunity, expecting scholars to be self-motivated and research inclined. Furthermore, the mentors found the group sessions the most beneficial due to enriched conversations among the collective group of mentors and mentees. Mentors also noted that a better alignment of research projects with student aspirations and a more focused semester-end deliverable (e.g. REU application) would enhance the program's structure. To ensure adequate time to fully develop a deliverable, faculty mentors believed that scholars should explore research interests during their first semester before being paired with a mentor. Finally, the need for professional development for faculty centered around how to better support first year students interested in research, was identified as crucial to scaling up the initiative.

Scaling-up Attempt

During the following academic year (Cohort 2 S-STEM Scholars) *Sprouting Research from Year 1* was modified to have all Engineering Ahead students (*n=20*) begin exploring research interests during their First Year (first semester) Seminar class. This allowed for more time during the second semester STEM-Persistence Seminar to focus on developing their research and putting together a summer research endowment application as their final project. Although scholars in Cohort 1 worked one-on-one with a faculty mentor, due to our attempt of scaling up (from *n=4* to *n=20* students), we were unable to recruit enough faculty mentors for the same 1-1 mentoring model. Instead, a second semester STEM-Persistence Seminar was co-taught by the mathematics faculty member coordinating Engineering Ahead and an engineering faculty member who served as one of the research mentors the previous year. Because the STEM-Persistence Seminar was offered to all Engineering Ahead Scholars, we were able to introduce the idea of research first to a larger population of our underrepresented students on our campus but differences in student feedback revealed the powerful influence of the 1-1 faculty mentoring.

Professional Development Workshop Series

Although high impact engagements (like research opportunities) are extremely beneficial for student retention, many faculty members on our campus have reservations about working on research with first year students. At the same time, faculty members also indicate that they find it unfortunate that they might only have 1 year (a student's second year) to work with students on research before they transfer to our flagship campus to complete their 2+2 program.

The first accelerator grant helped spark more local conversations about undergraduate research and recently a fellows program was created for two faculty members to help centralize and coordinate undergraduate research initiatives happening on our campus. Recognizing the struggles of recruiting faculty mentors when attempting to scale-up *Sprouting Research from Year 1,* the second accelerator grant was used to develop the following 5-part professional development workshop series on how to better engage first-year students in undergraduate research.

Workshop 1: Mentoring Undergraduate Research Student

- Presenters: Undergraduate Research Faculty Fellows
- Objective: Discuss best practices and opportunities for working with undergraduate research students across all STEM disciplines.
- Attendance: 28 STEM faculty members
- Outcome: This was the first time that all STEM faculty members (not just Engineering) were in the same room speaking about low-income students. This has helped initiate partnerships as we develop Biology Ahead, a new summer bridge program in 2025.

Workshop 2: Latino/a/x Undergraduate Student Experiences

- Presenter: Engineering Education Researcher & Author
- Objective: (1) How to best serve our growing population of Latina/o/x students and what it means to be a Hispanic Service Institution. (2) Mathematics Pathways; Community college to 4-year pathways; Enhancing the engineering student experience for Latina/o/x and low-income students.
- Attendance: 30 STEM faculty members, 3 administrators, 2 community college representatives, 2 local K-12 representatives
- Outcome: This started conversations on our campus about how to become an emerging HSI and we began collaborations for creating pathways for students in STEM fields from K-12 to community college to our four-year institution.

Workshop 3: Working with Generation Z Students

- Presenters: Coordinator of Learning Center & Coordinator of Student Support Services
- Objective: Help faculty better understand the educational experiences and skill sets that Generation Z students bring to our campus.
- Attendance: 24 STEM faculty members
- Outcome: This started conversations on our campus about how to better serve today's students. An entire faculty retreat was held at the end of the semester to continue this conversation.

Workshop 4: Finding and Creating Undergraduate Research Opportunities

- Presenters: Director of Student Research & Graduate Equity at the Center for Engineering Outreach and Inclusion
- Objective: Provide faculty with knowledge about all undergraduate research opportunities and resources across the university.
- Attendance: 18STEM faculty members
- Outcome: This started conversations about increasing awareness and accessibility of undergraduate research opportunities for both faculty and students.

Workshop 5: Working with S-STEM Scholars

- Presenter: S-STEM PI & S-STEM Scholars
- Objective: Provide faculty with an opportunity to engage with a panel of S-STEM Scholars about their ideas, challenges, successes and overall experience with conducting undergraduate research on our campus.
- Attendance: 22 STEM faculty members, 9 S-STEM Scholars
- Outcome: Rich dialogue between faculty and students resulted in several focus areas for which the faculty research fellows can work to address in coming semesters for increasing and improving undergraduate research on our campus.

Feedback from Professional Development Workshop Series

The 5-part workshop series aimed to deepen faculty understanding of undergraduate research and high-impact engagement practices, with a particular focus on mentoring first-year students. After completing the series, 13 faculty members responded to a satisfaction survey. The results indicated a high level of satisfaction with the professional development provided, with an average overall effectiveness rating of 4.4 out of 5. Additionally, the faculty reported a notable increase in confidence regarding their ability to support undergraduate research, as their average willingness to mentor first-year students rose from 3.2 prior to the series to 4.3 afterward.

Qualitative responses from the faculty participants also highlighted both the strengths of the workshop series and opportunities for growth. Participants described the workshops as informative, useful, and motivating, particularly valuing the diversity of topics. Materials and discussions were viewed as practical and relevant, with many faculty reporting increased readiness to support undergraduate research for first year students. Suggestions for improvement included offering more discipline-specific strategies and providing structured guidance for how to develop appropriate research experiences for first year students. Participants also recommended faculty panels, stronger support for new faculty, and a focus on how to best assess student research potential. Additional comments emphasized the value of ongoing programming, collaboration opportunities, and mentorship from experienced colleagues. Overall, the series successfully enhanced faculty engagement in undergraduate research and it is recommended that the workshop series continue with expanded topics and formats, including roundtable discussions and mentoring networks. Creating discipline-specific resources and fostering a faculty community of practice could further strengthen the impact of these beginning efforts on undergraduate research mentorship.

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