Board 403: The Influence of Belongingness and Academic Support during a Global Pandemic for Engineering Students through Participation in an S-STEM Intervention Project

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Abstract

The purpose of this S-STEM intervention project is to provide support for talented but financially needy students to increase degree completion and successful job placement in STEM fields. The project provides support through scholarship funding and participation in an academic cohort designed to provide experiential learning in career-relevant spaces. Students in our sample were completing their STEM degrees during the recent "COVID years", a time when they were not only at risk due to financial hardship, but also separated physically from teachers, peers, mentors, and opportunities. Although COVID had a negative effect on the types of experiences available to these students, participation in this program has helped them to thrive, persist and succeed. Through group meetings, guest speakers, career development participation and trips to engineering industry sites, the group developed professional relationships with peers and faculty, and belongingness within the university community. The Watson-Glaser Critical Thinking Assessment was employed in testing for cognitive flexibility, attitudes about STEM, grit, professional readiness. This psychological connection, made possible by this program, has led to academic growth and professional development which in turn has supported degree completion and job placement success. Specifically, students, despite a pandemic, showed growth in academic performance, cognitive skills, and career networks through the support of their S-STEM mentor, program guidance, tutoring, and internship opportunities.

I Introduction

Research in higher education has long focused on interventions based on theories and models designed to improve student outcomes. Experiential learning, city-based learning, and internships provide students with pathways to build skills and improve career outcomes [1] - [5]. This is especially important in STEM education to develop skills for the workplace and career networks. Thus, the NSF grant proposed scholarship funding and industry immersion experiences for a cohort of science students with financial need. This S-STEM Intervention Project is based in curricular and co-curricular enhancement at a small private liberal arts university to develop job skills and knowledge about science and engineering-oriented careers.

However, the "COVID years" disrupted this intervention by making it difficult to provide students with off-campus experiences in the first years in the learning cohort. Students in our sample were completing their STEM degrees during the recent pandemic, a time when they were not only at risk due to financial hardship, but were also separated physically from teachers, peers, mentors, and opportunities. Based on our desire to reap benefits from the intervention, even if we could not be immersed in learning experiences in the city, adjustments were made to the grant plan to include on campus activities to build a cohesive group, discuss professional fit and readiness, and connect to alumni and professionals by video call. Research on learning cohorts and belongingness also provide evidence for benefit to undergraduate students [6] - [8]. The sense of belonging to STEM intervention programming is considered a key contributor to success in STEM fields for underrepresented minorities (URM) students [9], [10]. Furthermore, the use of enrichment programs designed to foster scientific community, introduce students to research and mentorship, and improve academic outcomes have also been demonstrated ways to improve both participation and retention of URM and female student participation in the sciences [11] - [13].

II Methods

Students were selected to join the cohort based on interest in STEM, high school or first year academic record, and financial need. The cohort included Engineering and Biology majors. Twenty students were selected to participate in the cohort and the intervention began in Fall 2020. There was also a control group of matched science majors who did not participate in cohort activities, although some programming was open to all students. Students in the cohort participated in activities during the academic years of 2020-21, 2021-22, 2022-23 and 2023-24.

All students completed baseline measures of cognitive, personality/attitude and professional readiness factors at the start of the grant (Time 1). The standardized measurements include the Watson-Glaser Critical Thinking Appraisal [14], the Cognitive Flexibility Scale [15], the Attitudes about Science, Technology, Engineering, and Mathematics scale [16], the Short Grit Scale [17], the Self-Control Scale [18], social and academic involvement via CIRP Your First Year College Survey items (2008) [19], and the Professional Competency Self-Assessment Tool (NACE) [20]. Students complete an assessment at the end of each year including these standardized measures, as well as a program review.

Students in the cohort meet biweekly with PIs to engage in activities designed to enhance learning and professional success. In group meetings, students engaged with guest speakers, explored and discussed career development, and, eventually in the third year of the program, took trips to science and engineering industry sites. Table 1 presents some of the field trip sites student visited.

Table 1: Science and Industrial sites visited.

Physics and Engineering Cohort Activities	**Biology Cohort Activities**
Visit to MHub (Engineering firm in Chicago)	Inspiring Hope Through Action: An Afternoon with Dr. Jane Goodall
Visit to the McCormick Bridgehouse and Chicago River Museum	Visit Northwestern University Biotechnology Program and Synthetic Biology Center
Presentation on campus from MEPIS Engineers (Engineering firm in Chicago)	Visit Shedd Aquarium
Industrial visit to MEPIS	River Forest Preserve
Visit to the Museum of Science and Industry	
Visit to the Hill Group (Engineering firm in Chicago)	

In addition to professional development and peer socialization, program components included academic and personal advising, supplemental tutoring, and increased mentoring by engaged faculty members.

III Results & Discussion

Although COVID had a negative effect on the types of experiences available to these students, participation in this program has helped them to thrive, persist and succeed. Both cohort and control showed equal rates of retention (65%). However, retained cohort members were slightly more likely to complete a STEM major (86 vs 79%). Comparison of variables over time revealed a significant mean change in professional development for students in the intervention. At Time 4 (upon completion of 6 semesters), students had significantly higher scores in professional readiness, group membership, professional contacts, and academic involvement ($p < 0.05$). See Table 2.

Table 2: Comparison of cognitive, personality and career variables over time.

	Mean, Time 1	**Mean, Time 4**
Critical Thinking	23.0	23.8
Cognitive Flexibility	56.6	59.7
Attitudes toward STEM	110.31	112.92
GRIT	27.8	27.5
Work Self-Control	16.4	15.7
Interpersonal Self-Control	18.1	17.6
Professional Readiness	**14.2**	**15.8***
Contacts	**0.4**	**2.9***
Group Membership (On/Off Campus)	**1.7**	**3.3***
Social Involvement	20.8	20.3
Academic Involvement	**14.5**	**16.3***

Note. N- 12; * $p < 0.05$

Given the COVID changes to the planned intervention, qualitative results also point to belongingness as a key factor in supporting students' academic success and professional development. As a result of their participation in this program, the group developed professional relationships with peers and faculty, and belongingness within the university community. See Table 3. This psychological connection made possible by this program, in turn has supported degree completion and job placement success.

Engineering students in the cohort completed valuable internships while in the program (7 placements) gaining valuable skills training and improving their professional network in the industry. For those students who have already graduated (N=3), two have obtained jobs in the field and one has begun a graduate program. One of the May 2024 graduates in the cohort has also accepted a job at an engineering firm to begin June 1st. Full data is incomplete as the study is ongoing for enrolled cohort members.

Table 3: Qualitative Feedback regarding Professional Connections and Belonging

Dimension	Example Quotation from Cohort Member
Professional Connections	The regular bi-weekly meetings provided a sense of connection and community within NPU, even during pandemic challenges. Learning from fellow students' internship experiences and receiving guidance from cohort teachers on practical aspects like resume and cover letter creation was invaluable.
	It also gave me the opportunity to interact with people outside of North Park as well. Getting the opportunity to talk to numerous different STEM professionals throughout my involvement in the cohort gave me an opportunity to develop in a professional sense by learning different nuances that can't be taught in a classroom. The ways in which being a member of the cohort put me ahead contributed to my academic success by giving me the confidence that I could be successful following my graduation while I was still in school. This took off some of the stress that comes with going through college.
	Being a part of this cohort has allowed me to make professional connections with professors, students, and people in the science industry. Having these connections has allowed me to be more confident in reaching out for help and advice for my professional career and allowed me to follow my passions and help find jobs the interest me.
	Having the STEM cohort during COVID was beneficial because it allowed us to have guest speakers from different states.
	My experience with the S-STEM team had been amazing over the course of 4 years of my undergraduate studies. Not only was I able to network with various students in the STEM field, I was also able to get a glimpse of their specific field of study such as Zoology, Engineering, and Biology. Overall, this cohort was truly one of the best experiences I've had during my undergraduate studies.

Dimension	Example Quotation from Cohort Member
Belonging	This support network created a strong sense of belonging within the cohort but also motivated and empowered me to pursue internships and build a foundation for my career. The cohort's guidance played a pivotal

role in enhancing my academic success by providing real-world insights and preparing me for professional opportunities.

The participation in S-Stem cohort scholars helped me feel connected to the NPU community during COVID because it allowed me to interact with a variety people that it may have been difficult to interact with during normal times, but especially during COVID. Intermixed with all sorts of STEM majors, being part of the cohort allowed each of us the opportunity to interact with and learn from people from many different majors.

I'm very grateful for the STEM cohort because it was a place for me to connect personally with other STEM students who are facing similar struggles in terms of academic classes. The STEM cohort also was a reason to see a couple of classmates that I couldn't see during some classes since it was online.

It made me connect and network with various students in multiple STEM fields. In addition, being part of meetings and events in-campus or off-campus also gave me a sense of belongingness as I was part of a group of students that have similar values and interests as me. As mentioned earlier, this sense of belongingness contributes to the network that I've formed with various students that can give me guidance to my career goals.

Being granted this scholarship at North Park was truly a blessing for my career and growth as a student. I was so excited to get started exploring the real world and see what experiences it had to offer. Although COVID threw a wrench in our plans and the cohort, we still tried to find ways to connect to the community. Through zoom calls and Teams meetings, we were still able to talk to professionals in the industries we were intrigued in. Along with being in this cohort, the sense of community brought us closer in relationship and academically. Many of the students in this group shared the same major as me, meaning that whenever I had a problem with homework or needed a study partner for tests, there was always someone who had the same goals and drive as I. Being able to work with someone like-minded and goal driven is a tremendous help in study habits.

The S-STEM Cohort provided a sense of community for me with other STEM members outside of my major and allowed me to stay connected with my peers throughout the COVID-19 pandemic. Many of the relationships formed throughout this program led to me feeling comfortable reaching out for help with academic or personal issues I may have been having. Knowing I had support from the friends I made in this Cohort allowed me to feel more comfortable taking risks knowing I could lean on them if I failed.

The S-STEM Cohort allowed me to stay connected with peers in similar situations during a time of disconnectedness. The cohort continued the effort to connect us with each other and the NPU community even if we couldn't be in person during those COVID years. I believe this did a lot in my growth as a professional and helped lead me to the position I have today. That connection with my peers and the community during a difficult time built important people and planning skills that I utilize effectively in my everyday life. It not only supported my academic success but also my professional success.

This study has a few limitations related to the small numbers in the cohort and control groups. In addition, cohort members who were receiving scholarships were required to complete standardized data for each time point. Control group members, with less incentives, were less likely to complete the same data, making direct comparisons at each time point more difficult. However, quantitative data and qualitative data demonstrate gains in program objectives for cohort members. Students, despite a pandemic, showed growth in professional skills and career networks through the support of their S-STEM mentor, program guidance, tutoring, and internship opportunities.

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