BOARD # 420: Persistence Framework to Retain Low-Income, Academically Talented STEM Students

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Application of the Persistent Model to Retain NSF STEM Scholars and its Challenges – Funded by NSF DUE Division[1]

Abstract

The authors had a prior NSF STEM grant where several lessons were learned: there was a significant increase in female students, but concentrated in life sciences or biology, not in engineering and technology; female students dropped out of engineering pathways after the first calculus course at the rate of 33.3%, indicating a need to redesign the activities and implement more student-centered practices in Calculus I; and peer and faculty mentoring were important for retaining students. In 2022 Penn State Capital College (PSCC) received an NSF DUE grant and based on the lessons learned, a stronger evidence-based approach was added to the current grant to leverage the infrastructure that was built with a persistence of interest framework. Prenzel's Persistence of Interest model is defined as a special persistence and selective relationship between a person and an object, where persistence in this context means "*the maintenance of the relation by repeated, active engagements.*"

The current project objectives are to increase enrollment, retention, and the graduation rates of academically talented, low-income students who aim to pursue baccalaureate degrees in a STEM major through a focus on the persistence framework throughout their undergraduate program. To support the persistence model, we are focusing on four key components: Scholar Support; Team-Based Cohorts; Engagement Activities; and Multi-Level Mentoring (S.T.E.M.). These program components provide opportunities for the scholars to foster their persistence related to the rigor of the academics, and their commitment to the STEM programs.

Based on surveys of student perceptions on factors associated with persistence applied by an external evaluator for the first two years of grant, he found students held very positive perceptions regarding the quality of their relationships, instructors, and academics. Students had moderately strong perceptions of academics outside the classrooms and finances. The area with the lowest level of agreement was activities outside the classroom. These results suggest the faculty have built a strong program that students find helpful. Furthermore, students had a very strong agreement about the utility and importance of Calculus, a strong agreement for the enjoyment of Calculus and confidence in Calculus. Some students found the Calculus course to be difficult. In addition, results from surveys of student perceptions about factors associated with persistence, the external evaluator found that students held very positive perceptions regarding the quality of their relationships, instructors, and academics. Students had moderately strong perceptions of academics outside the classroom. The external evaluator also recommends that the program continues to be implemented with minor changes. Furthermore, results from focus group of students, the evaluator found that students held very high perceptions about the mentoring, tutoring, and other academic support provided to them. Students found some instructors to be fantastic and others to be average. Not all the faculty identified were associated with the program. He also found that faculty associated with the program provide outstanding support for all students and especially to students struggling academically.

1. Introduction

Based on the theoretical Prenzel's Persistence of Interest model[1-3], in 2022 faculty at PSCC received an NSF DUE grant with the following objectives: (a) Increase the number of diverse

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low-income, academically talented students who enroll in and graduate from PSCC STEM undergraduate programs, contributing to the workforce in the STEM frontier areas; (b) Implement curricular and supportive activities that promote scholars' persistence in STEM programs; (c) Identify factors that, from those curricular and supportive activities, contribute to scholars' persistence to remain in STEM undergraduate programs and successfully graduate; and (d) Disseminate knowledge about the role of S.T.E.M. components in promoting persistence in undergraduate STEM programs.

Note that PSCC is one of the premier institutions in Central Pennsylvania that provides STEM education. Data from PSCC Enrollment Services Office indicates a STEM enrollment increase of 24.11% for PSCC during the last six years. In addition, PSCC is located in Dauphin County, Pennsylvania, which has a 29% diverse population[4] that is reflected in its student population. PSCC serves the Harrisburg metropolitan area with a population of about 1.3 million, including some high-need school districts. PSCC is also in proximity to a state capital, commerce, and to a variety of industries that offers our students opportunities to be involved in internships, public service, and nonprofit organizations. PSCC offers programs leading to Bachelor of Science Degrees, where low-income scholars can enroll in the following STEM fields: Civil, Electrical, Mechanical, Computer Science, Mathematical Sciences, Biology, Life and General Sciences. Engineering technology options include Electrical, Mechanical, and Science, Structural Design, and Construction. All engineering programs are accredited by the Accreditation Board for Engineering and Technology (ABET). The school also offers graduate degrees in Computer Science, Electrical Engineering, Mechanical Engineering, Engineering Management, Engineering Science, Environmental Engineering, and Environmental Pollution Control. The school also houses two research centers: The Center for Signal Integrity and Central Pennsylvania Research and Teaching Laboratory for Biofuels.

2. S-STEM Student Support Services and Programs

The project aims to build off the current PSCC infrastructure and enhance the scholars' opportunities for social and academic integration and student-faculty interactions through a focus on four key components (S.T.E.M.): Scholar Support; Team-Based Cohorts; Engagement Activities; and Multi-Level Mentoring. These components are based on the Persistence of Interest Framework of Figure 1 and provide opportunities for the scholars to foster their persistence related to academic interest, the rigor of the academics, and commitment to the STEM programs.

For example, we implemented a STEM Scholars' Orientation Day during the first week of the semester to share the expectations of the program and additional requirements for scholars to maintain their scholarships where we explain the support system that exists for them to succeed. Academic support initiatives such as pairing scholars with an Academic Success Coach and with a peer, faculty, and industry mentor at the beginning of their first year are also implemented (multi-level mentoring). Scholars Persisting in Academic (SPA) seminars are also offered to alleviate the stress and anxiety that low-income students experience when taking high-stakes courses in STEM.

To promote the team-based nature of the cohorts[5-6], several activities are implemented; one being Team-Based Calculus. Calculus I is considered a gateway course not only because it "*significantly contributes to the STEM gender filter,"* [7] but because it also leads students to drop from STEM fields. The team-based curriculum is being implemented in a special section of

MATH 140 where the scholars are enrolled along with other undergraduate students. Other programs are undergraduate research and internships. We view participation in undergraduate research and internships as a venue for greater academic success for students who traditionally are underserved by education. At end of the second year of this grant, we have few students who are pursuing undergraduate research and internships (see results section). These students are greatly benefitting from these experiences and undergoing academic growth.

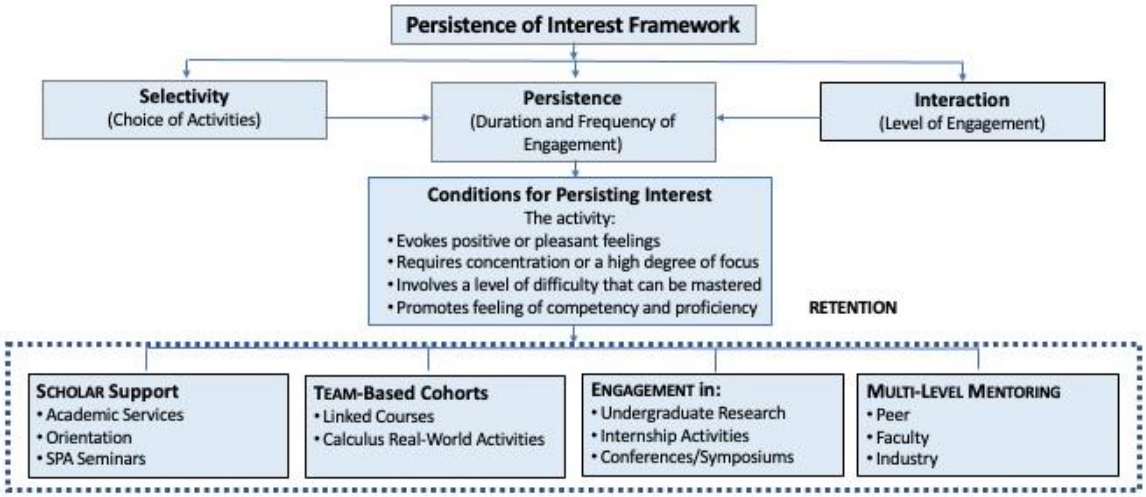

Fig. 1: Persistence of interest framework underlying the proposed project

Peer and faculty mentoring were offered. We identified peer and faculty mentors for the different majors. For the 2024 NSF STEM cohort, peer mentors were selected from the 2022 and 2023 cohort scholars. Faculty mentors were selected from the STEM departments at PSCC. The mentors were provided with training on expectations, frequency of meetings, and rules to approach the mentees. The authors view all the programs being implemented as essential components of the low-income students' persistence in STEM fields.

3. Data Collection, Data Analysis and Results

The evaluation was based on participants' grades, participation in activities, and attendance at meetings during the first two years of the program. An early Fall semester baseline survey measured scholars' background characteristics. An end-of-semester survey was administered to each participant that addressed the four components of the effort: Scholar Support, Team-Based Cohorts, Engagement Activities, and Multi-level Mentoring. Data collection was coordinated with the external evaluator while its analysis was entirely performed by the external evaluator. Sample survey data is shown on Tables 1a and 1b. Based on surveys, the evaluator also found students held very positive perceptions regarding the quality of their relationships, instructors, and academics. Students had moderately strong perceptions of academics outside the classrooms and finances. The area with the lowest level of agreement was activities outside the classroom. These results suggest the faculty have built a strong program that students find helpful. Furthermore, students had a very strong agreement about the utility and importance of Calculus, a strong agreement for the enjoyment of Calculus and confidence in Calculus. Some students found the Calculus course to be difficult.

From a focus group of students, the evaluator found that students held very high perceptions about the mentoring, tutoring, and other academic support provided to them. Students found

some instructors to be fantastic and others to be average. Table 2 highlights some of the data related to scholars' academics, relationship with instructors and outside classroom activities.

Table 1a: Quality of Relationships

Survey Items: Quality Relationships	% Any Agree	% Strongly Agree
I have plenty of friends among my fellow students.	79.1	18.6
It is easy for me to make new friends on campus.	74.4	27.9
I am satisfied with the relationships I have with my peers.	88.4	32.6
I enjoy interacting with my fellow students.	97.7	34.9
I have plenty of contact with fellow students outside the classroom.	67.4	25.6
I am satisfied with my social life on campus.	81.4	25.6

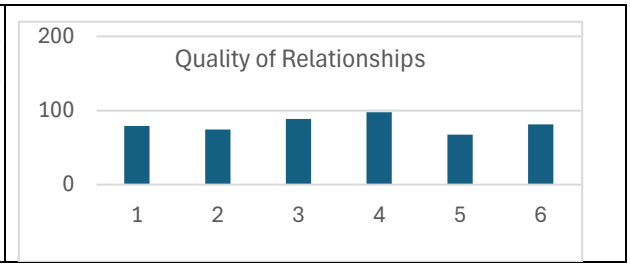

Table 1b: Confidence in Calculus

Domain Name and Item	2022 Cohort (N=5) Oct	Dec
Confidence		
I have a lot of self-confidence when it comes to calculus.	4.00	4.20
I can solve most of the problems in calculus.	4.20	4.20
I am confident that I understand calculus.	4.20	4.20

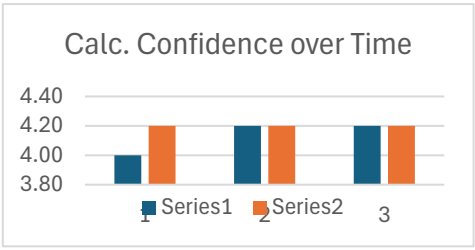

Table 2: Scholar relationship with the instructor and outside activities

Domain Name and Item:	Fall 2022	Fall 2024	Diff: 2024-2022
Instructors			
My instructors are generally good teachers.	4.87	4.86	-0.01
I am satisfied with the access I have to faculty members.	4.74	4.93	0.19
I am satisfied with my interactions with faculty members.	4.74	4.86	0.12
It is easy to interact with instructors and advisors.	4.91	5.07	0.16
Academics			
The academic advising offered to students is helpful.	4.43	5.00	0.57
I like the atmosphere in my academic program.	4.96	4.64	-0.31
My courses are interesting.	4.83	4.31	-0.52
I like to learn new things in my courses.	5.39	5.14	-0.25
I am satisfied with my academic development at this university.	5.00	4.64	-0.36
Academics Outside the Classroom			
I have opportunities to get involved in research projects that are related to my major.	4.09	4.29	0.20
I work with other students on schoolwork outside of class.	4.30	4.57	0.27
I discuss ideas from readings or class materials with other students outside of class.	3.96	4.46	0.51
I discuss ideas from readings or class materials with faculty outside of class.	3.43	4.08	0.64
I interact with faculty outside of the classroom concerning coursework.	3.91	4.23	0.32

In addition to the above, we note that so far, we have three NSF STEM scholars who have pursued undergraduate research. One at Hershey Medical Center, "*ATP synthase leak channel is the molecular target of thyroid hormone induced mitochondrial uncoupling*," other at Mississippi

State University on *"Environment-Aware Mobile Intelligent Edge"*, and one at PSCC on Artificial Intelligence. One NSF STEM scholar did an internship at a local construction company and another at a state agency.

For the most part, students are successful. All but one of the students have acceptable GPAs and are persisting in their STEM major. During the focus group, several students communicated that they found the mentorship provided by faculty and peers to be incredibly useful. Early intervention is a key to helping academically struggling students and to then provide them with support. The qualitative and quantitative data in the evaluation report indicate the NSF program is being implemented with fidelity and has demonstrated commitment on the part of all faculty involved in promoting the NSF Scholars' success. As per the evaluator, the scholars have demonstrated their active involvement in the program's activities and have not only persisted but have succeeded in their academics, especially the introductory calculus course. The program's emphasis on peer and faculty mentoring, targeted seminars, and attendance at tutoring sessions all played a pivotal role in offering scholars the specialized support to help them navigate the challenges of their initial years in a STEM major. More importantly are the scholar journals' appreciation for the holistic and inclusive approach, sample quotes such as "*Simply put, the program has really inspired me to achieve academic greatness. I was able to finish my first semester with a 3.8 GPA, and I truly believe it was because of this program,"* or *"Another thing that helped me immensely was the peer mentoring. I had a peer who was assigned to talk to me and explain how to go about college and study tips. When things got a little difficult for me near the end of the semester, I talked with my mentor about what I was struggling with and we worked out what I had to do and the extra tutoring I would need."* Given the overall survey results as well as the scholar quotes, highlight the importance of the program activities in fostering scholars' persistence in STEM field.

Acknowledgements

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