

Board 198: An Innovation-Themed National Science Foundation S-STEM Grant Program

Dr. Karl D. Schubert FIET, University of Arkansas

Dr. Karl D. Schubert is a Professor of Practice and serves as the Associate Director for the Data Science Program for the University of Arkansas College of Engineering, the Sam M. Walton College of Business, and the Fulbright College of Arts and Sciences.

Dr. Carol S Gattis, University of Arkansas

Dr. Carol Gattis is the Associate Dean for Special Projects in the Honors College and Adjunct Associate Professor in Industrial Engineering at the University of Arkansas. She has 30+ years of successful STEM educational program design, development, and research relative to engineering and honors student recruitment, retention, diversity, international education, innovation, and course development.

Xochitl Delgado Solorzano, University of Arkansas

Xochitl Delgado Solorzano is the director of the Honors College Path Program at the University of Arkansas. In this capacity she oversees all aspects of the Path Program, including recruitment and student success, grant requirements, and fundraising.

Jennie S Popp Ph.D.

Jennie Popp, Ph.D. is a Professor of Agricultural Economics and the Associate Dean of the Honors College at University of Arkansas. As Associate Dean, Dr. Popp contributes to student success initiatives through the management of Honors College study abroad.

Dr. Paul D Adams, University of Arkansas

Paul D. Adams, Ph.D. Associate Professor, Department of Chemistry and Biochemistry Associate Professor, Cellular and Molecular Biology Distinguished Faculty Member, The Honors College University of Arkansas 119 Chemistry Building phone:(479)575-5621

Mrs. Leslie Bartsch Massey, University of Arkansas

Leslie Massey is an instructor in the First-Year Engineering Program at the University of Arkansas. She received her BS in Biological Engineering and MS in Environmental Engineering from the University of Arkansas. She previously served as a project manager.

Mr. Thomas Carter III, University of Arkansas

Chunhua Cao, The University of Alabama

An Innovation-Themed National Science Foundation S-STEM Grant Program

To enhance the competitiveness of the United States on a global scale through the provision of STEM graduates equipped with innovative skills, students must be educated in innovation methodologies. With the support of a grant from the National Science Foundation's Science, Technology, Engineering, and Mathematics Program (S-STEM), researchers at the University of Arkansas are focused on augmenting the number of STEM graduates who possess both training and experience in innovation. The program, *Closing America's Innovation Gap through Collaboration with Industry (NSF Award #2030297)* – herein referred to as INNOV – is designed to offer academic innovation opportunities, alongside scholarships and retention programming to facilitate student success [1, 2].

The structure of the INNOV program encompasses several components: 1) a credit-bearing innovation bridge program conducted during the intersession immediately before the students' initial semester on campus [1], 2) a year-long sequence of innovation courses featuring industry-partnered projects in the first year [2], and 3) innovation-themed field trips to various industries and startups. Additionally, the program incorporates a non-curricular segment known as the Path program, which includes a first-year residential community, peer and professional mentoring, faculty guidance, monthly cohort gatherings, and team-building exercises. INNOV scholars also are awarded scholarships to help reduce the financial barrier to success.

INNOV builds upon insights gained from a preceding NSF S-STEM grant initiative, *Closing the STEM Labor Gap through a Path to Graduation (PTG) for Low Income, Rural Students (NSF Award #1742496)* [3, 4, 5]. Feedback from PTG alumni highlighted the significance of their credit-bearing bridge program in achieving success. INNOV learned from this, preserving the popular non-academic and cohort-building portions while changing the academic component to focus on innovation. PTG's identification of student challenges enabled the INNOV team to proactively address many concerns to bolster retention rates.

INNOV recruited 28 students of which 7 (46%) are female and 15 (54%) are from historically underrepresented groups (HUG) (formerly termed underrepresented minority). All students are Pell Grant recipients with reported high school GPAs of 3.50+ and ACT of 23-27 (or SAT 1130-1300) upon INNOV application and program acceptance. This GPA and ACT/SAT combination is designed to reach students with potential but those who do not generally qualify for institutional scholarships. Further student demographics are provided below.

Student Selection

The selection of recipients for INNOV had a multi-phase procedure, including a written application, solicitation of letters of recommendation, and culminating in a final interview. The 15-minute interviews were conducted by a diverse panel consisting of INNOV program faculty and staff, representatives from industry, and student representatives from the STEM disciplines.

The implementation of an interview was based on lessons learned from PTG that after the first year instituted the interview to help select the best candidates. INNOV used the PTG procedure

but in addition, included letters of recommendation, and representatives from industry on the interview panels.

First-Year Intersession Bridge Program

First-year INNOV scholars engaged in an intersession bridge program specifically tailored for INNOV scholars [1]. This 2-week bridge program was held immediately before the regular fall semester. The program included a three-credit hour course designed to immerse students in the fundamentals of innovation. It allocated one credit hour each to the study of innovation processes and ecosystems, essential skills for success in the first year of university study, and an open-ended, project-based innovation exercise. This exercise emphasized teamwork and critical thinking and enabled students to analyze historical and contemporary STEM innovations and forecast future trends in innovation. Additionally, the intersession program incorporated peer mentoring and team-building activities, which are integral components of the retention strategies detailed in the subsequent section.

An anonymous survey was deployed at the end of the INNOV bridge program. 100% of respondents reported that the course furnished them with information anticipated to enhance their success at the university. 96% of participants affirmed that the course was instrumental in augmenting their comprehension of innovation and in fostering an appreciation for its significance. Approximately 92% of respondents indicated an increased comfort level with risk-taking and articulating their ideas after they participated in the class. 88% of participants felt that the course had a positive impact on their ability to think more creatively and innovatively in the future.

The earlier S-STEM program, PTG, held a bridge program that 100% of graduates considered vital to their success at the university. The PTG bridge program was initially 6 weeks long and was later moved to the 2-week intersession model because the 6-weeks in the middle of summer created financial and family hardship. This was the basis for the INNOV intersession program timing and length. One major difference between the grants, however, was that INNOV focused on innovation, and PTG focused on undergraduate research in the bridge program course.

First-Year Innovation Courses

The INNOV program introduced two foundational courses in innovation for first-year students, each carrying one credit hour, scheduled consecutively in the fall and spring semesters [2]. This educational sequence was designed to foster interdisciplinary collaboration between STEM and business students through engagement in innovation-centric projects in partnership with industry. These courses provided a comprehensive introduction to the innovation process, encompassing a range of critical topics. These included (1) the generation of ideas, (2) principles of the lean startup methodology, (3) project management techniques, (4) market analysis and assessment of user value, (5) fundamentals of intellectual property rights, (6) cost analysis procedures, (7) manufacturing processes, and (8) strategies for scaling operations from proof of concept, through the pilot phase, to full-scale production.

During the fall semester, students were immersed in the innovation process through a comprehensive curriculum that included interactive lectures delivered by field experts, prescribed

readings, access to online videos from specialists, and case study analyses. As the semester advanced, students applied their acquired knowledge to complete assignments and participate in in-class active learning exercises. In the final four weeks of the semester, students formed new teams to identify and propose the development of an innovative service or product. These proposals were articulated both verbally and in written form, followed by feedback.

In the subsequent spring semester, students leveraged the innovation process methodologies learned in the fall to further develop their proposals. The culmination of this semester involved students presenting their developed proof-of-concept or prototype through both a poster presentation and an oral presentation at the end-of-year symposium, showcasing the practical application of their innovation education.

Collaboration with Industry

The INNOV initiative fosters direct engagement between students and industry professionals, integrating real-world applications into the curriculum through project-based learning and field excursions beyond traditional coursework. The innovation courses offer students early exposure to hands-on, interdisciplinary team projects under the guidance of faculty and industry mentors. This early immersion into practical problem-solving with mentorship from both academic and professional spheres equips students with invaluable team collaboration and innovation skills. Furthermore, the inclusion of industry mentors from a broad spectrum of STEM and non-STEM fields enriches the program, allowing students to absorb vital insights and observe firsthand the application of innovation in various industry contexts.

Scholarships

To mitigate the financial challenges faced by these Pell Grant-funded students, the INNOV program has instituted a scholarship initiative designed to support students for up to eight semesters, contingent upon ongoing eligibility criteria. Students must maintain a 3.0+ cumulative GPA (CGPA), make adequate progress toward their STEM degree program, and actively participate in INNOV. Tuition and fees at the university average approximately \$9,700. Participants in the INNOV program received a scholarship package totaling up to \$7,450 for their initial year of enrollment. This package included a one-time, non-renewable scholarship of \$2,950 allocated for the fall intersession for first-year scholars to cover the bridge program cost, in addition to renewable scholarships of up to \$4,500 per year. The renewable scholarship of \$4,500 per year can be extended over a maximum of eight semesters. Furthermore, to foster academic excellence and engagement with the university's broader academic community, the program offers an additional incentive: an increase of up to \$1,000 per year in scholarship funds for students who achieve a minimum GPA of 3.50 and secure membership and active participation in the Honors College, an opportunity available from the second semester onwards.

Students who do not fulfill the retention criteria stipulated by the INNOV scholarship program can petition the PI to be allowed a probationary status and be given a semester to re-attain satisfactory academic standing. During the probation period, the academic progress of the student undergoes rigorous scrutiny, and the frequency of mentoring sessions is increased to provide enhanced

support. Failure to achieve good academic standing by the conclusion of the probationary term results in termination from the program, including termination of the INNOV scholarship.

The Path Program (Path)

The INNOV initiative has established a collaborative partnership with the Path Program (Path), which is dedicated to supporting the success of students from Historically Underrepresented Groups (HUG) who also demonstrate financial need in their collegiate pursuits. Path staff are in the Honors College. Insights gained from the work conducted under the PTG grant have been instrumental in informing Path's strategies to enhance retention rates among HUG and rural students facing financial challenges. As part of this collaborative effort, Path oversees the co-curricular elements, employing a suite of further refined INNOV strategies below.

Academic Success Advising: INNOV program participants benefit from a dual-layered advisory system. Beyond the departmental faculty academic advisor, students engage in consistent consultations with professional non-faculty advisors. These advisors are tasked with assisting students in navigating both academic and social challenges encountered throughout their tenure in the INNOV program. Early identification of students exhibiting signs of academic or social distress prompts advisors to direct these individuals toward suitable support resources.

INNOV Monthly Meetings: Integral to the INNOV program are monthly cohort-building meetings, held three times each semester. These sessions are designed to cover a spectrum of topics, including experience mapping, diversity and inclusion training, management of academic and social expectations, and planning for academic objectives. These gatherings also serve as a platform for INNOV scholars to forge connections with peers, fostering a sense of community and facilitating the exchange of advice and experiences.

Faculty-Student Interaction: A cornerstone of the INNOV experience is the close collaboration between students and STEM faculty members. This relationship extends to both the mentoring and project development aspects of the program. Personalized mentoring sessions delve into curriculum planning, postgraduate education pathways, and career opportunities, providing tailored guidance to each student.

Living Learning Community (LLC): As first-year students, INNOV scholars reside in an LLC situated in the HC residence hall. This arrangement immerses students in an environment optimized for academic endeavors and offers direct access to HC programs. Additionally, it enables natural cohort bonding and integration into the Honors College's vibrant academic and social ecosystem.

Honors College (HC) Programs: Students demonstrating exemplary academic performance (GPA of 3.5 or higher) will receive invitations to join the Honors College. This membership opens the door to a wealth of resources, including funding for research and travel, access to signature seminars, specialized honors courses in STEM disciplines, and enhanced academic advising services, further enriching the INNOV educational experience.

PTG provided Path with an opportunity to learn how to better retain HUG and rural students with financial needs who have high school academic preparation at the level of our INNOV scholars. The evaluation of retention strategies for rural, historically underrepresented Pell Grant recipients within PTG has illuminated several critical factors necessitating targeted intervention. Their work allowed INNOV to implement these strategies from the start, since PTG students and INNOV scholars have the same incoming student GPA and ACT/SAT requirements, all are Pell Grant recipients and the majority come from under-preparing schools. A paramount discovery was the significance of affirming the students' sense of worthiness and belonging at the university. For rural students, there is often a lack of familial experience with higher education and financial constraints that limit their access to resources commonly available to their peers, such as advanced technological devices and apparel. Initiatives to foster an inclusive environment, wherein students are reassured of their valued place within the academic community despite apparent disparities, have proven beneficial. This approach underscores the importance of cohort solidarity in mitigating feelings of isolation and having regular conversations with the scholars on their worthiness of being at the university.

With PTG, it was learned that peer mentors needed additional training and materials to enhance support mechanisms for these cohorts. Therefore, peer mentors were equipped with comprehensive resource kits encompassing topics pertinent to the mentees' needs. This strategy not only facilitated immediate mentor responsiveness outside conventional working hours but also ensured that mentors were adequately prepared to address a broad spectrum of inquiries and concerns. These kits have worked well for INNOV scholars.

Addressing the educational disparities stemming from under-resourced preparatory backgrounds, the program implemented proactive measures to encourage the utilization of tutoring services, thereby normalizing academic assistance. Furthermore, adjustments were made to the standard STEM curriculum for the first year for PTG scholars. The same has been done for the INNOV scholars, who enter the university with similar academic preparation. This modification entailed staggering the introduction of demanding courses such as calculus, chemistry, and physics within the first year to alleviate the academic load and accommodate the scholars' need for academic acclimatization.

Additionally, it was recognized that PTG scholars often require more structured guidance in time management and a deeper understanding of student responsibilities regarding class participation and coursework management. Enhanced instructional support in these areas was identified as a crucial factor in improving this demographic's academic success and retention rates and was therefore implemented for INNOV scholars.

INNOV Scholar Demographics and Persistence

INNOV scholars were required to be low-income Pell Grant eligible, have an ACT of 23-27, and a high school GPA of 3.50+ at the time of application and acceptance. In the data below, some students have ACT above the 23-27 range. This is due to students taking the ACT an additional time that was reported to the university after the INNOV application and acceptance were completed. Some students' high school GPAs can be higher than 4.0. This is because Arkansas requires the use of a weighted GPA for assessment and consideration of scholarship eligibility.

Under this system, most courses are assigned a standard credit value of 4.0. However, an enhanced credit value of 5.0 is assigned to Advanced Placement (AP), International Baccalaureate (IB), honors, and concurrent credit college courses which are deemed more academically challenging.

The demographic characteristics of the INNOV scholars are shown in Table 1. The first cohort of the INNOV program recruited 12 students (7 females, 5 males) before the fall semester of 2021 began. These students exhibited a range of high school GPAs from 3.64 to 4.16 ($M = 3.96$, $SD = .16$), and their ACT composite scores varied from 24 to 28, with 11 participants (one individual did not undertake the ACT; $M = 25.82$, $SD = 1.47$). Two male students (constituting 16.67% of the first cohort; one Hispanic and the other White) withdrew from the program for diverse reasons, departing in distinct semesters of the 2021-2022 academic year. For those who persisted in the program until the end of the spring semester in 2023, their cumulative GPAs ranged from 2.69 to 3.94 ($M = 3.30$, $SD = .48$).

In the subsequent year, cohort 2 admitted 16 students (6 females, 10 males) before the fall semester of 2022 began. The high school GPAs of these students ranged from 3.67 to 4.30 ($M = 3.99$, $SD = .18$), while their ACT composite scores ranged from 24 to 29, encompassing 14 records (two students did not undertake the ACT; $M = 26.57$, $SD = 1.83$). Moreover, one female student of Hispanic background, possessing a 4.0 GPA in her initial semester, opted to transfer to another educational institution in spring 2023. For those cohort 2 students who persevered in the program until the end of spring 2023, their cumulative GPAs ranged from 2.82 to 4.00 ($M = 3.50$, $SD = .35$).

Spring 2023 ended with 25 students in the program and an overall 89% retention rate to date. Cohort 1 retention after the sophomore year was 83.3%, and Cohort 2 first-year retention was 93.8%.

Table 1. INNOV Demographics and Persistence (N = 28)

Recruitment	Cohort 1 (n = 12)		Cohort 2 (n = 16)		Overall (N = 28)	
	Count	%	Count	%	Count	%
Gender						
Male	5	41.70	10	62.50	15	53.60
Female	7	58.30	6	37.50	13	46.46
Race						
Asian	4	33.30	1	6.30	5	17.90
Black or African American	1	8.30	3	18.80	4	14.30
Hawaiian/Pacific islander	1	8.30	–	–	1	3.60
Hispanic/Latino	3	25.00	6	37.50	9	32.10
White	2	16.70	6	37.50	8	28.60
Two or more	1	8.30	–	–	1	3.60
Rural						

Yes	3	25.00	2	12.50	5	17.90
No	9	75.00	14	87.50	23	82.10
First Generation						
Yes	6	50.00	7	62.50	13	46.40
No	6	50.00	9	37.50	15	53.60
# Students Left Program					Cum	%
2021	2	16.67	–	–	2	16.67
2022	–	–	1	6.25	3	10.71
Persistence	10	83.33	15	93.75	25	89.29

As was discussed earlier, INNOV implemented and refined retention strategies that were developed during the PTG grant work. Although many things can influence retention, the INNOV team believes that beginning these PTG-learned new retention strategies and best practices in the students' first year was a strong factor in INNOV's retention. For example, INNOV sophomore retention for its cohort 1 was 83% while PTG was 43%. INNOV did not have any cohort 1 students leave the program in their second year. INNOV's cohort 2 first-year retention is equivalent to that of PTG (93.8% vs 92.3%, respectively), and it does not appear at this point that INNOV will lose any students in their sophomore year. If so, then at the expected 93.8% INNOV retention will exceed the PTG sophomore retention rate of 73%.

Sophomore Survey

At the end of their second year, INNOV sophomores were asked to reflect on their experience in an anonymous survey. Related to the innovation experience courses in their first year and how it impacted them in their sophomore year courses and/or in life outside the classroom,

- 81% felt the courses helped them feel more comfortable expressing their ideas.
- 76% said the courses helped them feel more comfortable taking risks.
- 63% felt the courses were valuable to their future educational and career goals.
- 54% said that the courses helped them be more creative and innovative.
- 54% felt that the courses helped motivate them to continue in their STEM degree program.

Related to the non-academic Path portion of the INNOV,

- 73% felt that Path was important in continuing their chosen degree program.
- 73% said Path was important for their social engagement at the university.
- 73% felt that Path promoted their sense of belonging.
- 72% said Path was important in promoting their academic engagement such as faculty interaction, attending class regularly, academic advising, etc.
- 62% said that Path motivated them to do their best.

Conclusions

The INNOV program has had a generally positive impact on participating students, particularly in boosting confidence, encouraging risk-taking, and increasing motivation within STEM disciplines. By providing a platform for students to express their ideas, the program created an environment conducive to self-expression. Additionally, it promoted innovation by encouraging students to explore new ideas and concepts outside of their comfort zones. Most participants recognized the value of the skills gained through INNOV for their professional development. Moreover, the program helped maintain students' enthusiasm and commitment to their academic pursuits. Further refining the program could enhance its effectiveness and address any areas needing improvement. Building on PTG was an important and successful strategy.

Acknowledgment

This material is based upon work supported by the National Science Foundation's Division of Undergraduate Education (EHR/DUE) under S-STEM Grants #2030297 and #1742496. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

- [1] Schubert, K., & Delgado Solorzano, X., & Massey, L., & Gattis, C., & Popp, J., & Cao, C., & Carter, T., & Muralidhara, D. (2022, August), *A Successful 2-week Innovation- and Student Success-Focused Bridge Program for First-Year Students*. Paper presented at 2022 ASEE Annual Conference & Exposition, Minneapolis, MN. <https://peer.asee.org/42080>
- [2] Schubert, K., & Gattis, C., & Delgado Solorzano, X., & Massey, L., & Popp, J., & Cao, C., & Carter, T. (2023, June), *Developing and Implementing Innovation-based Academic Content and Experiences for First-Year Low-Income Students*. Proceedings of the 2023 ASEE Annual Conference & Exposition, Baltimore, MD. <https://peer.asee.org/42694>
- [3] Gattis, C., & Adams, P., & Delgado Solorzano, X., & Popp, J., & Lo, W., & Muralidhara, D. (2023 June), *Helping Rural and Underrepresented Students Succeed in STEM*, Proceedings of the 2023 ASEE Annual Conference & Exposition, Baltimore, MD.
- [4] Adams, P., & Delgado Solorzano, X., & Lo, W., & Gattis, C., & Popp, J. (2020, June) *Closing the STEM Labor Gap Through a Path to Graduation (PTG) for Low Income, Rural Students*, Proceedings of the American Society of Engineering Educators Annual Conference (Virtual), Montreal, Quebec, Canada.
- [5] Gattis, C., Delgado Solorzano, X., Nix, D., Popp, J., Cleary, M., Lo, W., Hill, B., & Adams, P. (2019, June). *Work in Progress: A Path to Graduation: Helping First-Year Low Income, Rural STEM Students Succeed*. Proceedings of the 2019 ASEE Annual Conference & Exposition, Tampa, Florida. 10.18260/1-2—33585