Bridging The Gap – Increasing Access And Preparedness For Post-Graduate Opportunities In The Biological Sciences For Student Transferring From A Rural Community College

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Abstract

Increasing the representation of skilled workers in STEM fields has been a priority in the United States, with a particular emphasis on supporting underrepresented groups. While urban areas with established higher education institutions have made efforts to engage underrepresented students in STEM, this study sheds light on the challenges faced by rural regions, especially those lacking 4-year institutions.

In this context, the "2+2" model, where students complete their associate degree at a community college and then transfer to a university for their bachelor's degree, has gained popularity. Rural community colleges, however, often lack the infrastructure and professional opportunities leading to disparities in STEM education.

To address this gap, the Northern Arizona University (NAU) – Yuma branch campus implemented the SEEDS program, funded by a National Science Foundation S-STEM grant. This program offered financial aid, academic support, and mentoring to students transferring from local community colleges to pursue a bachelor's degree in Biological and Natural Resource Sciences.

This article presents the program's methodology, including recruitment and financial support, academic support such as tutoring and advisement, and professional development through STEM seminars and field trips. The results highlight the program's success in recruiting and supporting underrepresented students, promoting academic progression, and enhancing post-graduation success, including employment and graduate program enrollment.

In general, scholarship programs such as SEEDS have a significant impact in attracting and retaining underrepresented groups in STEM in rural areas and we advocate for continued funding to support the growth of STEM education in underserved regions.

Introduction

Increasing the number of skilled workers in Science, Technology, Engineering, and Mathematics (STEM) has been a priority in the United States for well over a decade (Johnson, 2012; Olson & Riordan, 2012). In particular, much effort has also been expended into reaching out to and supporting underrepresented groups in STEM (e.g. women, Hispanics, African Americans, Native Americans, and the disabled) (Ashford-Hanserd et al., 2020). In urban metropolitan areas, often diverse areas in of themselves, institutions of higher education have strived to reach out to underrepresented groups to support them in STEM degree attainment by leveraging a wide and often established infrastructure.

In particular, rural areas with only 2-year community colleges and no stand-alone 4-year institutions of education more than likely will lack the corresponding infrastructure and scientific research endeavors that accompany them and should not be ignored (Handel, 2007). In these cases, the community's demand for higher educational opportunities may produce new and novel partnerships to be developed to attain degrees in higher education – especially in STEM (Loeser et al., 2021). A popular endeavor that has developed with community colleges and universities is a "2+2" model. In this model students complete their associate degree in their first two years (lower division course work) and then transfer to a university to complete their bachelor degree in the subsequent two years (upper division course work) (Foley et al., 2021).

Rural community colleges, which may provide the academic portion of a student's higher education progression, can lack the additional professional development opportunities that their peers at the university will receive in their first two years in part due to them being commuter campuses and having a low density of STEM interested students. Thereby when a rural community college student in STEM transfers to a university they may be academically ready for upper-division course work but are woefully behind in their professional/career development (Wang, 2015). To address this need, the Northern Arizona University (NAU) – Yuma branch campus implemented the SEEDS program which provided financial aid, professional development, and mentoring to students transferring from the local community college (Arizona Western College, AWC) to complete a bachelor of science degree in Biological and Natural Resource Sciences.

Demographics of the Region

NAU – Yuma branch campus is located in Yuma, Arizona, a rural community in the southwestern part of the state, borders the state of California (Imperial county) as well shares an international border with Mexico, and is comprised of 62% Hispanic, 33% White with about 14% of the total population holding a bachelor degree or higher (Arizona: 31% Hispanic, 56% White, and 28% bachelor degree or higher; US Census Bureau 2015 data). With no stand-alone 4-year college or university in the region AWC partners with NAU in the life sciences for a 2+2 program. Established in 2008, students in this 2+2 model typically pursue an associate degree in either biology or environmental science and then transfer to the university branch campus (shared campus with a dedicated university science building) to complete a bachelor of science degree in biological and natural resource sciences (BNRS). Graduates of AWC who would want to pursue a different life science degree would otherwise need to leave Yuma for one of the main locations of the state universities in Flagstaff, Tempe, or Tucson – a large financial and sometimes personal burden for many in the region. On average, the BNRS degree has approximately 30 $\pm$ 5 students (juniors and seniors) in the program at any one time – which lends itself to a close knit science community with limited course offerings each semester to maximize course enrollment (average, 10 $\pm$ 2) that, however, fosters the natural formation of student cohorts and allows for the faculty to know each student.

Methodology

The SEEDS Program

Funded by the National Science Foundation's (NSF) Scholarships in STEM grant program in the Fall of 2015 the SEEDS program aimed to support each student for two years in order to complete their bachelor degree (for a total of 30 students) after transferring from AWC or other nearby community colleges (2015-2020). The program consisted of three core areas that utilized multiple evidence-based student support structures.

I. Recruitment and Financial Support

Students were recruited from AWC and Imperial Valley College (IVC; El Centro, CA) by way of campus visits to general biology, general chemistry, and introductory environmental science courses as well as science department meetings (brochures and applications were handed

out and made available on our program website). The application consisted of asking for basic identification information, demographics, grade point average (GPA), relevant course work, a personal statement addressing their interest in science and how this program would benefit them, and three references. In general, the application was designed to be as simple as possible for the student to minimize any barriers for applying.

Once a semester, the scholarship committee, consisting of the principal investigator (PI), program coordinator, another NAU faculty member, and a member of the community, reviewed and scored applications pending availability and funding in the program. In general students who had GPAs of 2.5 (NAU minimum) or higher and were close to finishing their associate degree program were brought in to be interviewed. The interview consisted of a set of general questions that would allow the student to address and elaborate on their career interests, academic preparedness, and reasons for wanting to be in the program. After each set of interviews, the scholarship committee would rank applicants based on their application score and interview. The top candidates would be selected and notified of the scholarship offer, whereby the NAU Office of Financial Aid would determine if they were eligible to receive federal financial aid (up to a maximum of $10,000/year, a value set by the S-STEM grant). [As of 2019 annual tuition and fees at NAU-Yuma are $8,365]

II. Academic Support

Professional Travel

Each year in the program a SEEDS scholar would go on at least one field trip outside the Yuma area. Field trips would consist of either a science conference, natural history excursion, and/or graduate school visit (Larose et al., 2009; Soldner et al., 2012). To minimize expenses, all trips were planned to be within a 6-hour travel time radius (one-way). Planning and budgeting for each trip would begin at least one semester before the event (setting dates, communicating with on-site personnel, etc.) with students being notified of travel dates at the beginning of semester that travel would occur to allow them to plan accordingly to minimize any academic disruptions.

Tutoring

Organic chemistry, genetics, and biochemistry were identified when the program started to be courses that our transfer students typically struggled with (note: although organic chemistry is taught by AWC our students typically would enroll in this course in their junior year concurrently with their NAU courses). To help facilitate success in these courses the SEEDS program required participants to attend tutoring sessions in these subjects during the semester in which they were enrolled in said subject (Meling et al., 2013). Sessions were open and available to all students in the science program with attendance recorded for each session to track SEEDS and non-SEEDS participation. A weekly hour and a half session would be offered for each course (organic chemistry and genetics, Fall; biochemistry, Spring) that was led by a paid tutor. The tutor was encouraged to meet with the faculty member of the indicated course to discuss learning strategies and topics for the semester. Recent graduates of the program whom had performed well in the course were recruited to be tutors.

Faculty-Driven Advisement

All NAU students are provided an academic advisor who will discuss their academic coursework based on the catalog requirements of a student's specific degree plan. SEEDS scholars were required to additionally meet with their faculty mentor (F. Villa, PI) to develop individual academic plans (IAP) that consisted of 2-year progression plans with manageable course loads (i.e. avoided stacking multiple academically challenging courses together in a given semester), elective courses catered to desired career choices, suggestions for summer professional development, and any other academic suggestions to improve their success in the program (Lancaster & Xu, 2017). IAPs were designed to be very flexible so that if a student needed to change a course or their career plans changed they would just meet with the faculty mentor to make any adjustments as needed. The faculty mentor often used these times to engage the students in discussions of their academic progress and intended career pursuits (Chelberg & Bosman, 2019).

III. Professional Development

Weekly STEM Seminar

A weekly 1-credit seminar (BSC 399, Special Topics) was used each semester to meet with SEEDS students to discuss, in a relaxed atmosphere, topics and issues important to a science major and relevant to our students that was lacking in traditional coursework (Wilson et al., 2012). It was determined that most of our students lacked STEM-related career guidance and any previous introductory courses on scientific ethics. The Fall semester of the seminar emphasized science career development: resumes, curriculum vitae, personal statements/cover letters, possible career choices and the availability of job openings, and alternative career planning. The Spring semester involved a discussion of a novel or non-fiction book regarding ethics in science as well as encouraging students to work on seeking additional professional development (attend a seminar/webinar, seek job openings or paid summer research experiences, participate in professional societies or student organizations, etc.). This session would alternate each week between a book discussion and professional development activity throughout the semester. SEEDS participants were required to enroll in this course every semester but the course was open to all students. Students were assessed mainly on attendance and participation.

Soft Skills Workshop

In the week before classes started each Fall semester SEEDS scholars were required to attend meetings and academic workshops (typically 2 to 3 days, 4-6 hours each day depending on topics). Based on previous experience, faculty in the science program noted students had trouble managing the following soft skills areas: efficient academic study skills for science courses, student financial planning, and time management. The workshops began with introductions by the faculty and students with brief updates on their summer activities and career plans followed by expectations of being a scholar in the SEEDS program, an overview of the semester, and then sessions on the designated soft skills areas. Soft skills sessions involved either Advancement Via Individual Determination (AVID) trained faculty, peer-tutors, or former graduates of the program (Goonatilake et al., 2010; Scaramozzino, 2010).

Post-Graduate Preparedness

An overarching theme with the SEEDS students was to emphasize a holistic approach to post-graduation preparedness via faculty mentoring/advisement, STEM seminar, field trips, and soft skills workshops based on previous studies (Dika et al., 2016; Narum, 2008; Olson & Riordan, 2012). Most of our students become so focused on the academic part of attaining a degree but fail to visualize and plan for their careers successfully after graduation. Some of this is due in part to limited higher education social currency (first generation college students whose only exposure to people with degrees in science are physicians, pharmacists, and dentists) and/or have been mis-advised about prospective careers, demographic availability, and competitiveness (MacPhee et al., 2013).

Results

Academic Progression

One of the main objectives of the SEEDS Program was to recruit and financially support 30 students for their last two years of undergraduate study over the span of the 5-year grant period. The SEEDS program was promoted extensively with our partner community college, AWC, via classroom visits to 100-level general biology, general chemistry, and environmental science courses – courses common for degree majors in the life sciences. Promotional material was also given to faculty at the neighboring Imperial Valley College (60 miles) science program in El Centro, California. All students that completed the application were given an interview with the SEEDS scholarship committee. Students that were admitted into the program were notified immediately and their financial need was subsequently determined by the NAU office of Financial Aid. Almost all of the students recommended for admittance into the program were eligible to receive support from the SEEDS program (Table 1). The two stu-

dents that were not eligible for financial aid through the SEEDS program in Year 4 (2018-2019) indicated that they wanted to participate in all the activities at their own expense because they liked the close-knit comradery that the program had fostered with students.

Once admitted into the program each student met with the faculty mentor of the science program to discuss their tentative career goals and to develop an IAP. Some students career goals changed and as a result they would meet with the faculty mentor to revise their IAPs. Over the course of the program students did not need their IAP to be modified too extensively – most changes often involved adding or extending internship experiences. Students generally reported that they valued the IAPs and the faculty expertise associated with managing reasonable course load and that they liked having their courses over two years planned out ahead of time (Chelberg & Bosman, 2019)technology, engineering, and mathematics (STEM. Many indicated that they wished a similar experience would have been available to them at their community college (Packard et al., 2013).

In the first year of the program SEEDS recruited and provided scholarships for 14 students followed by the addition of 5, 8, and 7 new students (Table 1) in subsequent years to maintain an average cohort size of 12.8 students awarded the scholarship each year (Kalevitch et al., 2012; Lei et al., 2011). In total 35 students were financially support with scholarship money from the SEEDS program with 33 (94%) of them being made up of individuals typically underrepresented in STEM. Most of our underrepresented students were predominantly Hispanic (77%) and/or female (74%).

The BNRS program requires students complete at least 3 units of fieldwork experience (i.e. internship) or undergraduate research. Both courses can be repeated for additional credit and the students make the decision which they would like to complete (with the option to complete both if they so desire). The SEEDS students overwhelmingly completed local internships (Figure 1). Less than half completed undergraduate research. The sum of these percentages indicate some students opted to complete both experiences. Although it wasn't required, we had over 10% complete undergraduate research at other institutions through paid summer research programs such as the NSF research experiences for undergraduates (REU) and other similarly sponsored.

At the end of the grant period 30 of these individuals graduated while in the SEEDS program with an attrition rate of 14% (5 students, Table 1). Those that left the program early did so either because they had personal issues arise that were beyond our control (N = 2), wanted to step back from being enrolled full-time (N = 2), or left the program completely for a professional graduate program (N = 1). Four of these five that left the SEEDS program early have since graduated from our department with their bachelor of science degrees while the one who left for a professional program has attained their doctorate in dentistry. A brief look at the 4-year graduation rates shows that our graduation rates are almost double to those of transfer students with a declared biology major on our Flagstaff campus (Figure 2). Although dramatically different we think the difference in graduation rates are due more so to our Yuma campus being designed specifically for transfer students.

	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	Total (Unique Individuals)	% of Financially Supported
Recruited	14	5	8	7	0	37	
Financialy Supported	14	15	14	13	8	35	
STEM Underrepresented	13	14	14	13	7	33	94%
Hispanic	11	11	10	9	5	27	77%
Female	9	10	10	8	6	26	74%
Graduated	2	9	6	4	8	30	86%
SEEDS Attrition	2	0	1	2	0	5*	14%

* - 3 students that withdrew from the SEEDS program eventually graduated with their degree

Table 1. SEEDS participant data collected throughout the duration of the grant period.

Student Experiences

Over the course of two years a typical SEEDS student will participate in a soft skills workshop, graduate school trip, science conference, and/or natural history fieldtrip. The soft skills workshop, which would occur the week before classes started every Fall semester, initially focused on effective study skills. It was identified early on when the program was being developed that our incoming student population (incoming junior transfer students from the community college) had not quite properly developed the study skills necessary to excel in their upper division science course work. We had access to AVID trained faculty from our education department and decided to try AVID-based training sessions on critical reading and Cornell notetaking. It was quite clear from student feedback and direct observation that AVID techniques are inadequate for science major based courses at the college and university level. We shifted to offering and subsequently keeping workshops on managing finances (taught by a former student that was a part-time employee by a certified public accountant) and study skills our tutors find useful in science courses. Although feedback was much more positive with revised soft skills workshop students appeared reluctant to come to campus before a semester started.

The concept of attending a graduate program to earn a graduate degree in science is a difficult to grasp concept for many of our students whose general exposure to anyone with a post-graduate education are typically those with professional degrees (e.g. physicians, pharmacists, dentists, etc.). To introduce students to this concept and their consideration of this in their career planning we scheduled semi-annual visits to a graduate program throughout the duration of SEEDS in biology or closely related graduate programs within the region. The visits typically consisted of meeting the graduate program coordinator, graduate students, and faculty and ended with tours of laboratory facilities. Institutions visited included The University of California, San Diego (Biological Sciences Doctorate Program), San Diego State University (School of Public Health Masters Program), The University of Arizona (Arizona Biological and Biomedical Sciences

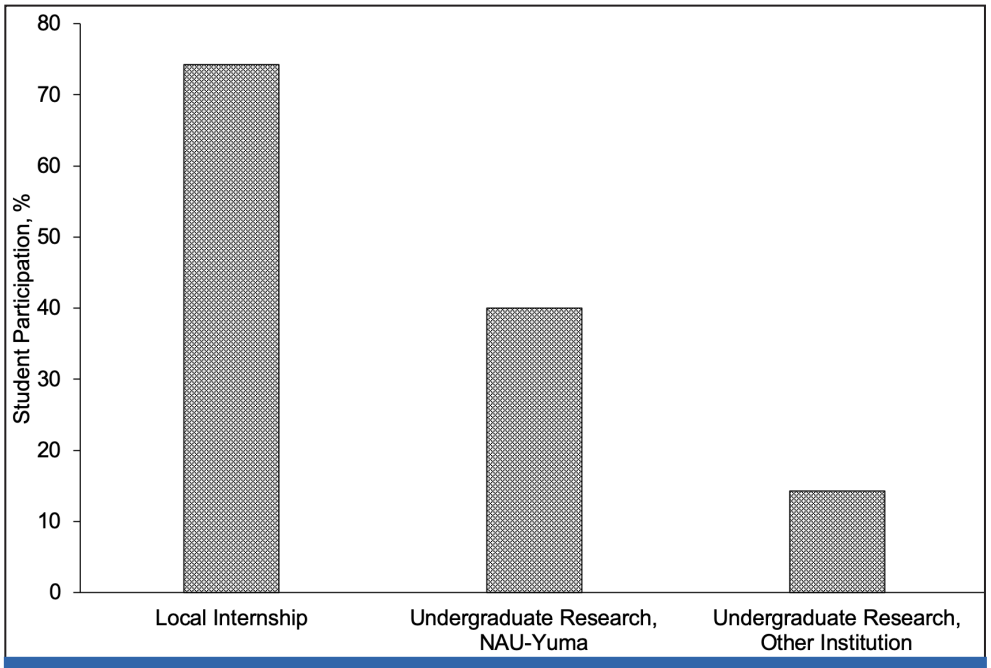

Figure 1. Percent of SEEDS scholars participating in local internships and undergraduate research.

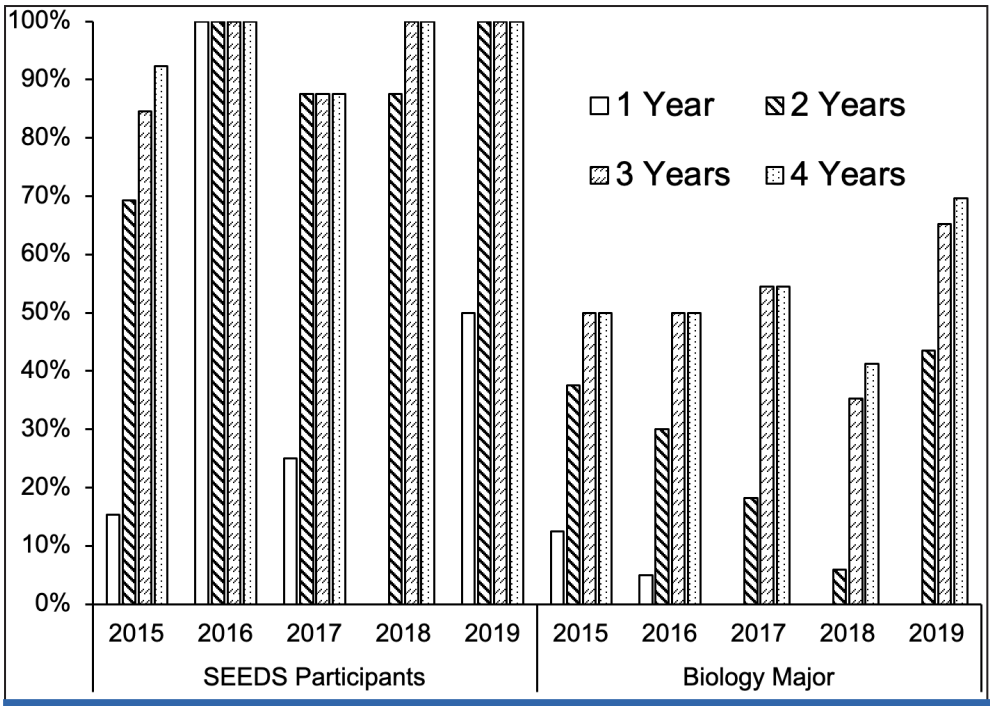

Figure 2. Four-year graduation rates of SEEDS participants compared with biology major transfer students on the main campus.

Doctorate Program), and Northern Arizona University (Biological Sciences Graduate Program). Students were overwhelmingly engaged with each graduate program trip and were appreciative of learning firsthand of these programs as potential options in their career paths.

As a result of these graduate program field trips several of our students applied for and were accepted into summer undergraduate research programs associated with some of these programs. Since graduation we have had four SEEDS students admitted into and accepted into graduate programs – whereas previously the science program had had only one student enter a graduate program in just under a decade. The four SEEDS students that entered graduate programs indicated that the field trips strongly influenced their decision to pursue a graduate degree and at the institution they visited.

Although Yuma is mainly an agricultural community, many of our students have very limited experience and education of actual desert ecology in the region. Each of the graduate school trips were designed to also include a natural history component to give our SEEDS scholars the opportunity to experience first-hand the ecology and natural resources of the area with additional field trips planned in alternating years during the Spring semester as well. Places visited included San Onofre State Beach (Oceanside, California), The San Diego Natural History Museum, Madera Canyon (Green Valley, Arizona), Colossal Cave (Vail, Arizona), The Arizona Sonora Desert Museum (Tucson, Arizona), Merriam-Powell Research Station (Flagstaff, Arizona), Lava River Tube (Coconino County, Arizona), Organ Pipe Cactus National Monument (Pima County, Arizona), and Mount Lemmon (Pima County, Arizona). In order to help make the field trip excursions financially sustainable, money from the grant was strategically used for purchasing camping/cooking/outdoor equipment in addition to consumables (e.g. park fees, food, etc.). A major cost associated with field trips are lodging and food. By utilizing camp sites/research stations for housing and also by making our own meals (compared with meals from restaurants) we saved us approximately 75% of our normal incurred expenses thus making this a low institutional cost per student (≤ $90/student).

Post-Graduation Success

Post-Graduation Success for the SEEDS Program was defined as either direct employment or enrollment in a graduate/professional program after graduation. Consistent with the trend seen in participation in local internships a majority of SEEDS scholars obtained direct employment (60% of SEEDS participants; Figure 3) with 31% in a STEM industry, 16% as primary/secondary science educators, 8% in health industry, and 5% in a non-STEM related career. Sixteen percent of the program participants entered a masters (5%) or doctorate (11%) graduate program and 24% entered professional schools for specialized degrees in health care. There was some overlap with three students gaining direct employment while also subsequently seeking and enrolling in a graduate/professional degree program.

Discussion

What worked?

At the end of the program we felt that we had several student-focused strategies that were tested and demonstrated to be effective and sustainable for our science program and student base - small state-funded transfer university in a rural agricultural and border community with limited higher education infrastructure. Practices that we will institutionalize as a result of this NSF S-STEM funded program will be focused on faculty-lead academic advising with the creation of IAPs, STEM seminars, and graduate school/outdoors field trips. The IAPs, initially time consuming in learning how to navigate graduation and degree requirement, are a great tool for students and faculty to connect. Students are drawn to meet with a faculty to get an IAP because many are unsure about what

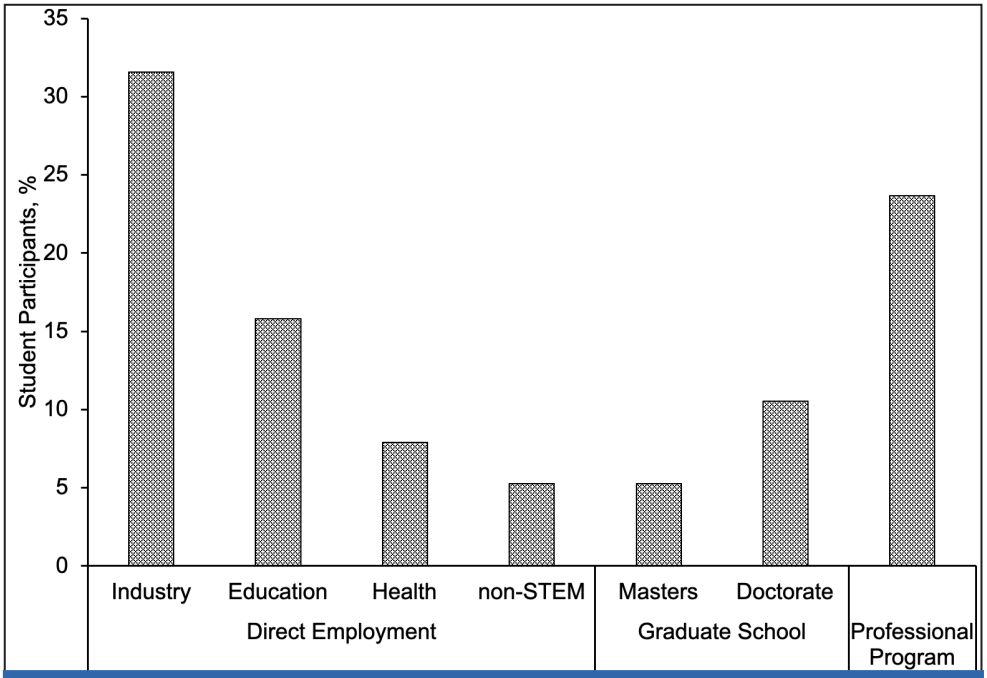

Figure 3. Percentage of SEEDS scholars that pursued post-graduate employment, graduate school, and/or professional programs.

courses they should and/or need to take to complete their degree. The time taken to meet, however, allows for mutualistic benefit in that the student to get familiar with the faculty member (many students reported hesitancy in talking with faculty because they may feel intellectually inadequate or do not want to "waste" the instructors time) and vice versa.

The STEM seminars – Science Career Development (Fall) and Science Ethics (Spring) – evolved from simple seminars addressing issues we saw with students not planning for careers after they graduate (i.e. dealing with the "jobs will be ready for you once you get a degree" myth) as well as providing students with a platform to discuss issues in science that they often never had experience with. In its final form the Science Career Development course had students develop a professional portfolio with information on what skills and experience they need for their careers along with planning for alternative paths early in their junior year. The Science Ethics course allowed the science faculty to follow up on the Fall planning while starting to engage the students in popular novels or books with science themes or topics. On their own, students would not normally enroll in these courses but by adding them to our degree plan as each one credit requirements students would enroll in them and not feel over burdened with additional course work. We also found that having students create professional LinkedIn profiles and join our science program group allowed us to better track their career progression once they left our program. Many have used this avenue since their graduation to send job announcements at their places of employment or career networks to graduating students and alumni of the program.

The graduate school/outdoor field trips were sustainable and valuable to the program in that we made them very affordable and it exposed students to educational opportunities and natural resources that they typically would not seek on their own. Students reported much more interest in the Arizona graduate programs we visited (e.g. more affordable and attainable) in addition to physically seeing what these programs offered and entailed. Before the SEEDS program we had one student in a 10-year span enter a graduate program (masters in statistics) and since then we have had on average at least one student/year enter a masters or doctoral science program. Several of these students reported that before the SEEDS program they were considering professional programs in medicine – mainly because their only exposure to advanced degrees was from their healthcare providers (e.g. physicians, dentists, pharmacists, etc.). These field trips also had a serendipitous effect if they lasted for at least 2 nights. We saw that when students in the program were physically interacting with each other for an extended time greater than their usual classroom associations they developed their own supportive cohort, a finding consistent with previous data (Graham et al., 2013; Lei et al., 2011). Being a small science program students already know and see each other every day and develop a marginal supportive cohort, but when they spend several days together, such as on a field trip, the amount of peer academic and emotional support increased dramatically (Ashford-Hanserd et al., 2020; Hall et al., 2017; Hansen et al., 2023) Unfortunately, this is strictly anecdotal and not very quantitative, we felt we could see this change, for the better, in a majority of our students. Students that previously reported a disconnect with classmates, whether real or perceived, often felt better about their interactions and gained some level comradery after a fieldtrip experience. Also, because the faculty mentor was on these trips it allowed students to interact more with their instructor on non-instructional time which allowed students to feel that the instructor was more approachable.

Tutoring and the soft skills workshops, although they showed some benefit to student success, will not be institutionalized (Meling et al., 2013). Although tutoring and the soft skills workshops were open to all students in the science program we saw very little participation with non-SEEDS students. Even though the SEEDS scholarship committee felt these events were valuable many SEEDS participants only attended because they were obligated to so because of the SEEDS scholarship.

The Scholarships

A major draw for students to choose the SEEDS program (or a science program in general) for this area is the scholarship money. Some students in the program indicated that they were not sure what they would have done after completing their associates degree if they had not received the SEEDS scholarship to finance their bachelor degree over the next two years. The scholarship itself allowed students to not have to work part-time (or full-time) jobs, often in the service or retail industry, and gave them the time to find internships (paid and unpaid) in their STEM career areas – it was a great focal point for student motivation and success. Students in this region rely heavily on financial aid through Pell grants, scholarships, and to some degree loans. Interestingly enough students in this region are often hesitant to utilize loans to finance their higher education expenses even though it may ease the amount of financial stress as compared to when they feel compelled to work. Some SEEDS students took on loans for non-educational related expenses such as a new car for commuting to campus or work.

Conclusion

As a result, we cannot stress enough how funding basic financial and academic infrastructure can have a significant impact on STEM quality, increasing underrepresented student populations and skilled workforce availability in rural and/or border communities. Unfortunately, the current trend of funding from federal agencies focuses on novel and innovative academic and financial support infrastructures rather than actual needs of certain institutions in rural regions that lack the student support infrastructure components that are commonly seen in metropolitan areas. It would not surprise us that many other institutions in rural regions may also lack these basic support structures and would benefit greatly with funding focused on fundamental support. Interestingly enough, we saw just how much of an impact scholarships alone had on attracting STEM students, enrollment, and graduation. Perhaps rural institutions would benefit greatly in growth and success of students in STEM, especially from underrepresented groups, with grant opportunities designed for renewable funding or continued funding from their respective grant agency.

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