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Integrated Academic, Research, and Professional Experiences for 2-Year College Students Lowered Barriers in STEM Engagement: A Case Study in Geosciences

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ABSTRACT: Two-year community college (CC) students face many barriers for recruitment and retention into Science, Technology, Engineering, and Math (STEM) fields and vertical transfer to 4-year universities (4YUs). Experiential learning, mentoring, and cohort building are effective mechanisms for increasing STEM recruitment and retention, and close collaborations between CCs and 4YUs leverage complementary opportunities, supporting vertical transfer. We present a case study incorporating these concepts for a year-long Geoscience Education and Outreach Program (GEOP), a collaboration among a CC, a 4YU, and a non-profit science center, where 20 CC students participated in integrated academic, research, and internship components over three years. We present program design, implementation, revision, and outcomes for both students and institutions. Cohort-building activities encouraged professional conversations and built peer connections that addressed imposter syndrome, cultural divides, and other personal barriers to vertical transfer. The academic component had the highest completion rate, and a majority of respondents in exit interviews reported the internship as the most valuable experience, with half naming research or aspects thereof as most valuable. The vertical transfer exceeded typical CC rates, with 70% of GEOP students transferring to a 4YU, all in STEM disciplines. Successful implementation of GEOP required multi-institutional coordination, effective mentor-mentor and mentor-student communication, and program flexibility. Based upon our experiences, we provide several recommendations for implementation of similar programs.

INTRODUCTION

Science, Technology, Engineering, and Math (STEM) disciplines face a continuing struggle to build a diverse and robust work force. Two-year community colleges (CCs) are highly diverse in terms of student population served and resources and curriculum they provide (Long, 2016; AACC, 2021). With one of the primary missions of CCs being vertical transfer to 4-year universities (4YU) (Cohen et al., 2014; Handel, 2013), these institutions offer valuable resources such as small class sizes, low tuition, academic and career mentoring, and individualized support services to prepare and expand our nation's STEM workforce. About 49% of the students who earned their bachelor's degree were enrolled in a CC in the previous 10 years (NSCRC, 2017). Even though more than half of all first-year college students in the US attend CCs (Ginder et al., 2015; Shapiro et al., 2016) and 80% of these students declare their intent to earn a bachelor's or a higher degree, the vertical transfer rate to a 4YU is only 30% (Shapiro et al., 2017).

Complicating STEM workforce development, STEM fields account for only 7% of CC enrollments, excluding technician- and health-related programs (Van Noy and Zeidenberg, 2014). In addition, even though CC STEM students persist in their majors compared to non-STEM students, only 16% earned a Bachelor's degree in a STEM field within six years after their CC enrollment (Van Noy and Zeidenberg, 2014). Major barriers for transfer in STEM disciplines include issues with college navigation and credit transfers, lack of time and money, poor academic preparation, poor advising and mentoring, imposter syndrome, cultural divide, and unsustainable recruitment and retention programs (Olson and Labov, 2012).

Many programs exist to lower barriers to STEM recruitment, retention, and vertical transfer for CC students. Three of the most effective elements for increasing recruitment, retention, and participation of undergraduate students in STEM, both at CC and 4YUs, are experiential learning, mentoring, and community building (e.g. Blake et al., 2013;

Wolfe and Rigges, 2017; Cooper et al., 2019; Jin et al., 2019; Krim et al., 2019; Trott et al., 2020; Van Noy and Zeidenberg, 2014; Walkington et al., 2020). Experiential learning, both inside and outside the classroom, such as capstone experiences, internships, course-based research programs, and summer research programs, increases communication and team building (Lopatto, 2004), increases self-efficacy and career ambitions (Carpi et al., 2017), reduces cultural isolation through use of cohorts (Gasiewski et al., 2010), and enhances relevance of course materials. In general, participants in experiential learning activities improve discipline-specific knowledge and skills and learn about broader research-related career paths. Such experiences also impact retention through increases in grades and graduation rates (Deek et al., 2003; Fechheimer et al., 2011; Graham et al., 2013; Byars-Winston et al., 2015; Rodenbusch et al., 2016; Krim et al., 2019).

Mentoring helps students navigate challenging psychosocial situations; mentors can provide advice, guide and supervise career paths, and act as role models (Beals et al., 2021; NASEM, 2017). A variety of mentors, including faculty, postdoctoral scholars, graduate students, and peer undergraduates, could form a collective support structure to positively impact students' professional confidence, sense of belonging in the discipline, and STEM identity (e.g. Paglis et al., 2006; Eagan et al., 2013; Byars-Winston et al., 2015). Many mentoring programs enhance persistence in STEM (Byars-Winston et al., 2015; NASEM, 2017). Strong mentor-mentee interactions help increase retention in STEM and improve grades and persistence in college, with stronger impacts for students from underrepresented groups and CC students (Nagda et al., 1998; Crisp, 2010; Bordes-Edgar et al., 2011; Linn et al., 2015).

Cohort building impacts students' sense of belonging and identity, creates social relationships, enhances commitment, and helps overcome cultural barriers in transfer to 4YU (Karp, 2011; Tovar, 2013). The sense of belonging to a supportive group with shared interests increases persistence (Seymour et al., 2004). Female students particularly value positive interactions within the cohort (Lopatto, 2004). Such interactions offer developmental advantages when used as resources and sounding board for ideas (Hunter et al., 2007). In addition, cohort building and engagement contribute to successful vertical transfer (Lee and Frank, 1990; Laanan et al., 2010).

Despite well-known benefits in lowering barriers in STEM fields through experiential learning, mentoring and community building, implementation at CCs remains challenging, primarily due to lack of infrastructure and low funding levels (NASEM, 2016). In addition, the cultural barriers posed by faculty may be higher at CCs since they serve more diverse student populations including first generation, underrepresented minorities, non-traditional students, and students who are older, have families, and/or are working part- or full-time. Programs that provide academic, social, and financial support are needed for such communities (NASEM, 2011). In addition, CC faculty are not expected to develop research programs due to heavy teaching loads. For example, in 2016-17, less than 1% of full-time faculty and students at CCs participated in research experiences (Hewlett, 2016; Snyder et al., 2019).

Close collaborations between CCs and 4YUs may lower barriers for vertical transfer by leveraging complementary opportunities available at both types of institutions (NASEM, 2017). Course-based experiential learning and small introductory courses at CCs make it easier to create new components to an existing course, while the ongoing research programs at 4YUs offer greater opportunities for learning in an apprentice-style environment involving project designing and research mentoring. Vertical transfer is particularly difficult for STEM majors since the students at CCs typically need to take more introductory courses at the 4YU and may be underprepared (Hagedorn and DuBray, 2010; Monaghan and Attewell, 2015). For example, in their report, Van Noy and Zeidenberg (2014) recommended that STEM students who require more than six years to finish their education may benefit from improved transfer and articulation policies.

Collaborations among CCs and 4YUs can also benefit students in cultural and academic transitions, providing role models and easing vertical transfer. The National Science Foundation (NSF) and the National Institute of Health (NIH) have sponsored many CC-4YU collaborations. Some programs also include collaborations of CCs with non-profit organizations (Charlevoix et al., 2021), museums, and industries, in addition to partnering with 4YUs [for example pogil.org]. However, many CC-4YU collaborations are short-term summer programs, typically for students who have almost finished with their courses at CC, though some programs require commitments for multiple semesters or multiple years (Coyle et al., 2016). As well, many programs look at single components such as curriculum-based or research-based or internship/professional experiences in isolation. Integrated programs and those serving early-career students offer multiple opportunities for students to explore interests in a STEM field and may lower barriers for entry and vertical transfer.

The Geoscience Education and Outreach Program (GEOP) was a collaboration of a CC that did not offer a Bachelor's degree in geoscience-related fields with a 4YU and a non-profit science center (SC) developed to address barriers to recruitment, retention, and vertical transfer in STEM disciplines, specifically in geosciences. During its three-year implementation (2015-2018), GEOP provided year-long integrated learning opportunities to CC students for shared, immersive experiences in geosciences as a cohort, through content-based STEM courses at the CC, men-

tored research at the 4YU, and paid internship at the SC, and presentations at student research symposia at the CC or elsewhere. In addition, during a one-year program extension (fourth year), some students also took a one-semester course with a week-long study abroad experience and some shared their research results at professional conferences.

This paper presents design, implementation, revision, and outcomes of the GEOP, and provides insights for future implementation. We describe our recruitment and selection process, followed by implementation of the three major components: academic, research, and internship, as envisioned at the beginning of the GEOP and implemented in the first year. Finally, we discuss the evaluation and outcomes of GEOP leading to enhancements and improvements in its implementation. Outcomes include student feedback and recruitment and retention data. The insights and discussion focus on student experiences in GEOP to understand their interest, engagement, performance, and potential impacts on retention and vertical transfer. In this paper, we provide a summary of the exit interview results, with a focus on barriers encountered by CC students during the Program. For a more detailed analysis, the readers are referred to Stofer et al. (2021) for overall program impact and Matyas et al. (2022) for the research component.

METHODS

Program Design. The calendar-year design of GEOP centered around holistic engagement of 6-9 students per year in geosciences through three major components, viz., academics, research, and an internship (see Table 1). The core mentoring team included five primary mentors, four of whom were women in STEM; an academic mentor at the CC; three research mentors at the 4YU; and one internship mentor at the SC. In addition, an Honors Program advisor at the CC and several outreach and program coordinators at the SC regularly mentored GEOP students.

Recruitment and Selection. The academic mentor and Honors Program advisor conducted several recruitment efforts including, advertisements through the CC GEOP website, CC student newsletters, emails, CC campus tours, and in-class announcements. Interested students completed an application form (Lannon et al., 2021), and the core mentoring team recorded interviews with each applicant. The application and the interview questions were approved by the Human Resources department at the CC to ensure compliance with Equal Opportunity hiring and selection processes. This precluded asking any open-ended or follow up questions that were not pre-approved. However, the intent of the application and interview was also an experiential one for students without prior exposure to such a process.

After the interview, the mentoring team selected six participants to the Program, the number limited by funding, and up to three additional students (alternates in the first year). All students, except the alternates, that joined GEOP could expect to participate in the internship, based upon their satisfactory performance and engagement in other two components during the first half of the spring semester. However, the alternate students could participate in the internship in case any other student was unable to participate, provided their performance was satisfactory. All selected students and alternates were invited to a GEOP Kick-Off meeting in December (see Table 1) to welcome the new cohort and discuss program details, commitments, and expectations. In addition, the students signed a Commitment Form (Lannon et al., 2021).

Table 1. *Schedule of activities in the GEOP for three cohorts. The un-shaded cells represent activities conducted prior to the beginning of the Program for each cohort. The shaded cells represent year-long implementation of the three components for each cohort. Parenthesis indicates activity conducted for the first cohort only.*

Activity	Occurrence
Recruitment	August - September
Application and selection	October - November
Kick-off meeting	December
Research and Academic	January-May
Research	June-July
Internship and Outreach	July-August
(Research) and Academic	August-December
Exit interview	December

GEOP involved three highly diverse student cohorts, including under-represented students in STEM fields such as women, first generation, and non-traditional students, as shown in Table 2. Female students, first-generation students, and need-based Pell grant recipients, each comprised greater than 60% of the GEOP participants over the three years, with first generation and women students comprising more than 85% of the first and second cohorts, respectively.

Academic. The first component of the GEOP consisted of three courses. During the spring semester, students took two courses taught by the academic mentor at the CC. The first was an Honors section of an existing course in *Physical Geography* covering the physical environment with emphasis on terminology, general concepts, and relationships among the atmosphere, the biosphere, the lithosphere, and the hydrosphere [see syllabus in (Lannon et al., 2021)].

The second course was the *Geoscience Engagement and Outreach* Seminar course developed by the core mentoring team for the GEOP students. The academic mentor worked with the CC administration to allow students to either pay tuition and earn 3 credits for the course, or enroll in the course for 0 credit, avoiding the burden of tuition, while including the course on their transcript. The course initiated a transfer pathway to the 4YU and offered cohort building through

Table 2. *Demographics of the students who applied and participated during the GEOP. An * represents the number of alternate students; and bold text represents the category with highest number for each cohort. Each student may be classified in more than one category.*

Category	Cohort 1		Cohort 2		Cohort 3	
	Applicants (n=11)	Participants (n=6+1*)	Applicants (n=13)	Participants (n=7)	Applicants (n=8)	Participants (n=6)
Female	5	2	8	**6**	**5**	**4**
First generation	**9**	**6**	7	5	3	2
African American	1	1	3	1	1	1
Hispanic	3	1	1	1	1	1
Non-traditional	5	3	3	2	0	0
Veteran	1	1	0	0	0	0
Pell grant recipient	5	5	**9**	5	4	2
GED Certificate	1	1	1	1	0	0
Dual enrolled in high school	3	2	2	2	3	3
College credits from high school	1	0	3	1	4	3
Student Parent	0	0	1	1	0	0

out-of-class experiences; for example, students visited the 4YU campus via guided use of public transportation (free to students) to alleviate travel and parking burdens and become familiar with campus and research areas in which they could work. A portion of the class time was set aside for research meetings, supporting the research component throughout the semester. In addition, the students also attended an orientation at the SC to gain familiarity with their internship institution and connections between research and sharing research results with public visitors through outreach [see syllabus in (Lannon et al., 2021)].

During the fall semester, after the internship, the students enrolled in the *Geoscience Engagement and Outreach Capstone Seminar,* another new course developed by the core mentors to focus on professional and research development. Like the spring Seminar course, the students could enroll for 0 or 3 credit hours. During this course, the students were introduced to a variety of career paths in geosciences through guest speakers and visits to local businesses and government agency sites. The students attended workshops on career counseling, financial aid, and college transfer through the CC Career Center and prepared their transfer applications to 4YUs. The Capstone course was conducted in a hybrid style with in-person and online meetings in the first year [see syllabus in (Lannon et al., 2021)].

Research. The second experiential learning component of the GEOP was engagement in research projects at the 4YU during spring, summer, and fall semesters. The primary goal of such sustained engagement was increased development of content knowledge and research practices to help in vertical transfer (Sadler et al., 2010; Linn et al., 2015). The research topics and environment varied among the three mentors. The remote sensing in hydrology topic involved primarily working at an agricultural field site, with some computer-based analysis, while the hurricane research was primarily computer-based with GIS software, and the geoscience public engagement research involved creating and conducting interviews and surveys about data visualizations. The research environments of the three mentors varied from a large research group with undergraduate and graduate students, technicians, and postdocs in a collaborative research space, to a small research group with graduate students located in individual offices, to a primarily undergraduate research group. Even though all three mentors had prior experience in working with undergraduate and underrepresented students, including first-year students and those with no prior research experience, none of the research mentors had worked with students from a CC.

We matched two-three students with each mentor based upon their preferences in the application form and the interviews. Each year, more than two-three students chose projects with the same mentor; thus, some students could not be matched with their first-choice projects and mentor. Once matched with a mentor, the students conducted on- or off-site research for at least 5 hours per week during the spring and first six weeks of the summer semesters. Some students worked together on the same project, while others worked individually on their projects.

During the fall semester, after the internship, the students continued meeting with the research mentors and partners, as necessary, to wrap up their projects and prepare presentations for the Research in Undergraduate Education Festival at the CC or other professional conferences as a culmination of their research experiences. The research mentors provided feedback to their students in spring and summer based upon a rubric adapted from (Singer and Zimmerman, 2012), available at (Lannon et al., 2021). In addition, a research journal, progress, and presentation contributed to course grades for the Seminar and Capstone courses. Matyas et al. (2022) provides a detailed analysis of the research component of the GEOP.

Professional Internship. The third component involved a 6-week paid internship during the second half of the summer semester (see Table 1) at the SC located about two hours' drive from the CC. During the internship, the students lived in private housing close to the SC that they secured individually. They received a travel and lodging allowance, along with a stipend.

The internship, led by the mentoring team at the SC, was based upon years of their prior experience in summer programs with college-level interns. The SC used "Portal to the Public" (Storksdieck et al., 2017) program to help the students better understand communicating science and breaking down the research conducted at the 4YU into products for public audiences and K-12 teachers. The students worked in subgroups, often different from their research pairings, with multiple SC mentors that included exhibit designers, science program interpreters, human resource specialists, and program designers.

During the internship, the cohort received 32 hours of training per week. Students helped staff include their 4YU research in new experiences for the SC's exhibits and visitor and teacher programs. For example, the students developed a live program on satellites and a hands-on laboratory UV experiment, related to the remote sensing in hydrology research. Together, the students created a new 3-D science animation about climate change and experiences exploring soil composition through sensing technologies. Two students from the first cohort conducted demonstrations in a science technology convention hosted by the SC in January following their year-long engagement in the GEOP. Some students created curriculum kits for middle school teachers. The finished kits included teaching instrumentation such as rulers, a sediment flume, and sand for demonstrating and understanding four sections of the curriculum focusing on heat transfer; the importance of accurate hurricane forecasts and designing a shelter for hurricane safety; how Earth changes through weathering, erosion, and deposition; and tracking hurricanes and creating a weather forecast. While the kits were developed by students in the first and the second cohorts, two students from the third-year cohort conducted three workshops during which they provided these kits to 53 teachers representing 12 counties in Florida. Each year, all students presented their exhibits or demonstration projects at the SC as part of their internship.

Program Evaluation and Iteration. The goal of informal and formal program evaluations was to understand student experiences from both mentor and student perspectives, and assess quality and impact of the three major components of GEOP. Much of the *informal* feedback we report from students came directly from their interactions with the academic mentor and the Honors Program Advisor at the CC. Since the students interacted with them most frequently, they informally discussed any issues regarding inter-personal relationships within the cohort, their research progress, internship experiences, and travel and other logistics. The academic and research mentors provided informal feedback to the students regarding their progress in the three components during the weekly research meetings and monthly whole-cohort and mentoring team GEOP meetings (in years 2-3). The SC mentors provided informal feedback during the internship through weekly discussions and meetings with the students about their progress. In addition, the core mentors met biweekly to discuss and resolve any issues raised by the students, and the research mentors provided annual reflections to the academic mentor relevant to research components.

Students provided *formal* feedback for the academic component through institutional course evaluations (see Lannon et al., 2021). However, these had limited utility due to low response rates of 7-13%. We collected formal feedback for the overall GEOP including the research and internship components through pre-, interim- (at the end of spring semester), and post-program quantitative surveys and qualitative exit interviews. The academic mentor administered the online surveys in the Physical Geography class for the pre-program and interim feedback. The survey included a subset of questions from the Geoscience Concept Inventory (GCI) (Libarkin and Anderson, 2005); a section on science identity adapted from Wolfe (2013); a section on worldview (Kahan, 2012); and a section on ordinary science intelligence, an emerging measure of broad science understanding (Kahan, 2012). The core mentors chose GCI questions related to content of the Physical Geography course; we attempted to find questions from the instrument related to the mentored research but found none. GEOP participants, and in subsequent years, alumni cohort members repeated the survey at the end of each project year via email recruitment.

The core mentors co-designed the exit interview questions (Lannon et al., 2021) to identify GEOP-related barriers for participation, benefits of participating in the GEOP, most valuable component(s), and suggestions for improvement. The GEOP Advisory Board conducted the exit interviews December (see Table 1). The Board consisted of three science and education faculty from the 4YU who were not involved in the GEOP, to avoid any potential conflicts with students. The Board provided mentors with a single document for each cohort where all answers to each question were transcribed, anonymized, and rearranged to prevent identification of individual students to the extent possible based on combinations of answers. The mentors met annually with the Board members to discuss GEOP implementation and results from the exit interviews to strategize changes for the subsequent year.

PROGRAM OUTCOMES AND DISCUSSION

Over the three years, the GEOP provided 20 students with the opportunity to participate in an immersive experience through part-time course work, research, and internship. The year-long duration of the program provided additional time for the students to transition through different phases of research, from an observer to near-independent STEM researcher. Seventeen students (85%) completed all the Program requirements for the spring semesters. Participation declined during the summer and fall semesters, with a completion rate of 78% and 60%, respectively. Such engagement issues have also been reported previously by other longer-duration programs (e.g. Pallant et al., 2016). In their three semester program, Pallant et al. (2016) found that the length of the program was difficult for some students. However, they noted that reduction in the duration would have impacted the students' immersive experience.

The completion rate for each component varied and some students achieved partial completion. The academic component had the highest completion rate, with 95% students finishing their spring coursework (see Table 3). Primary reasons for those who were unable to complete the academic component for either spring or fall, based on feedback to the academic mentor, included poor performance, medical leave, increased effort needed for other jobs, and scheduling conflicts with other obligations. Out of the eligible students, 87% completed the internship component. Primary reasons for not participating or finishing internship included unsatisfactory performance in coursework and/or research in the spring semester, travel and financial hardships, lack of attendance, and medical issues. Eleven (55%) students completed all the research requirements of the Program, with six students finishing only spring research requirements. One student finished all the research and academic requirements of GEOP but could not participate in the internship as they were an alternate, while another student finished all requirements except the Capstone course and the final research presentation. It is worth noting that even though ten students (50%) completed all requirements of GEOP, the vertical transfer rate for GEOP was 70%. In addition, all transfer students have enrolled in STEM-related fields such as Engineering, Geography, Geology, Biology, Ecology, and Mathematics. This demonstrates the positive impact of the Program, irrespective of whether they finished all three components.

Effective implementation of GEOP required close coordination among administrative, financial, and technological units at the three institutions. Such coordination was particularly challenging for the CC in the first year because this was its first multi-institutional federal grant as a lead institution, managing a subaward. This funding mechanism and collaboration was, by design, fulfilling one of the goals of the NSF's IUSE:GEOPATHS Program to provide an opportunity to the CCs to improve their award administration and enhance curriculum while learning from 4YU institutions. The administrative procedures at the CC were inflexible for some of the GEOP's goals. For example, the mentors found the application and interview process of the candidates at CC to be too restrictive and discouraging for students who did not have prior experience in such processes. The application and interview questions approved by the CC administration were designed more for an employee hire and were inflexible for understanding student backgrounds and fit for the Program that was designed to particularly encourage non-traditional students.

The administrative procedures also included disbursement of funds to the SC and to the students during internship. The timely disbursement of the funds to the students was important because financial resources is one of the major barriers for CC students toward vertical transfer. For example, at the CC, typically 37% of full-time students receive the need-based Pell Grant. In GEOP, 12 students (60%) received Pell Grants (see Table 2). Administrative delays during the first

Table 3. *Number of students completing the GEOP components by student category. The number in parenthesis refers to transfer to a STEM-related discipline. *The total who started the internship was 15.*

Category	Phys.Geog Course	Seminar Course	Spring Research	Internship	Summer/Fall Research	Capstone Course	Final Presenation	Transfer to 4 YU
Female	12	12	11	9	9	9	8	9
First generation	13	13	11	8	9	7	7	9
Black	3	3	3	3	2	2	2	2
Hispanic	3	3	3	2	3	3	3	2
Non-traditional	5	5	5	4	4	7	2	3
Veteran	1	1	1	1	1	0	0	0
Pell grant	12	12	10	8	9	7	7	8
GED certificate	2	2	2	2	2	1	1	2
Dual enrolled	7	7	7	4	5	6	4	6
College credits from high school	4	4	4	2	2	3	2	3
Student parent	1	1	1	1	1	1	1	1
Total Students	20	19	19	13*	14	13	11	14 (14)

year led to late disbursement of stipends and living expenses well after the start of the internship. In addition, during the first year, all the funds were provided to the students in one installment and one student left the internship and the CC abruptly, immediately after receiving the funds; however, this student later reported back to the academic mentor that they are currently in a geoscience related career. The CC subsequently modified the fund disbursement process.

Coordinating access to technology and computational resources among the three institutions was a significant challenge during the implementation. To begin, the students needed official affiliation at the 4YU to receive computer accounts to access libraries and research software. Since the CC students were not enrolled at the 4YU, they could only be added to the 4YU personnel management system as visiting researchers. The process was lengthy during the spring semester of the first year and the students received access later in the semester, causing delays in starting research. Even with access, the online, remote use of the software was unwieldy. In addition, during the first year, the Program mentors found that not all students had access to computers at home for research or course assignments, and those that had access had different operating systems causing further inconsistencies. The SC mentors loaned laptops to students during their internship in the first year and for the program duration in years 2 and 3.

Similar to the CC students needing access to resources at the 4YU and the SC, the 4YU mentors needed access to the course websites at the CC for uploading assignments for the Seminar and the Capstone courses and providing research assessments. However, since the mentors were not instructors at the CC, the access remained a challenge and required cumbersome paperwork every semester. This access was discontinued in the fall of the second year and the 4YU mentors provided their assignments and assessments directly to the CC mentor, who uploaded them to the course website.

Results of the Program Evaluations. The course evaluations for Physical Geography had written comments from four students, who found the three courses enjoyable and the CC mentor to be a "*good teacher*." One student mentioned that they would have preferred more hands-on activities and assignments to improve their learning in the Physical Geography course. The non-anonymous internship evaluations from eight (out of nine potential) respondents in the second and third years were also positive, with all criteria rated above neutral. As shown in Table 4, the students provided high scores for training received from the SC staff and feeling comfortable approaching their supervisor to discuss any issues during their internship. In their written comments, the students reported that the internship helped improve their skills in public speaking, communication, time management, writing, critical thinking, facilitation styles, working independently, research, and teamwork.

Table 4. *Summative, non-anonymous evaluations for the internship component submitted by 8 (out of 9 potential) students in Cohorts 2 and 3.*

	Strongly Agree	Agree	Neutral
Human resources support	7	1	0
Supervisor support	5	3	0
Adequate training	8	0	0
Professional treatment	5	3	0
Realistic preview of field	3	3	2
Better prepared for workforce	6	2	0
Activities challenging and stimulating	6	2	0
Environment encouraged feedback	5	3	0
Good communication with supervisor for issues	8	0	0
Overall positive experience	8	0	0

In the feedback from exit interviews, summarized in Table 5, the students reported positive experiences in their cohort and in one or more components of the Program. The informal and formal cohort-building activities embedded within each component of the GEOP helped encourage professional conversations within the cohort and resulted in students forming a close-knit cohort. For example, a student from cohort 1 commented, "*we all knew each other pretty well, because we were taking seminar class in Spring, as well as the other class. We got to really get to know each other*" and two other students from cohort 2 mentioned, "*that's probably how I made most of the friends I made in Gainesville coming from high school …. We all became very close and we still hang out*", and "*the part that I really liked was being involved with the cohort; I've made lifelong friends*." From the academic mentor's perspective, by the time the cohort took the Capstone course in the fall, the students facilitated and encouraged each other to participate in career exploration events. The students also reported positive overall cohort experiences, such as,

> "[mentor] *took us to* [local engineering firm]…*to meet consultants. That was awesome. Meeting people in the field and actually getting in the field and doing things, and we went to bat cave… Of course, the people that I met…. Everybody in the cohort is really cool.*

The students appreciated different experiences provided by the three components, as shown in Table 5. Students from all three cohorts had positive experiences during the internship and 10 respondents found this to be the most valuable part. As also reported in Stofer et al. (2021), the students benefited from the work-experience and communication with visitors during the internship and found its structured implementation for hands-on activities to be a positive experience. Students also reported that the academic component provided them with experiences within their comfort zone

of taking courses. The academic component was the first exposure to geosciences for seven out of 16 respondents. Students appreciated the CC mentors' enthusiasm to help them in all aspects of the Program, and their guidance with transfer applications and geoscience-related careers.

As shown in Table 5 and detailed in Matyas et al. (2022), students benefited from involvement in authentic, hands-on research experiences. The GEOP was the first college-level, mentored research experience for all the students. Overall, five students reported the research experience as the most valuable part of the GEOP. In addition, some students mentioned specific aspects of the research experiences as the most valuable part, such as working with a mentor, presenting at a professional conference, and learning about what topics they liked and did not like. For example, a student from the second cohort captured the process and value of research well when they said,

> *I think having mentors to guide you on the way. I think jumping into research is pretty intimidating to most people, regardless of what you're researching, but when you have someone who has done it, and they're in the field that you're researching, it definitely helps. The mentors were the greatest part for me.*

About 50% of the respondents found the research component challenging and confusing in the beginning but some students became increasingly involved in their project with time. As shown in Table 5, most students felt unprepared for the time commitment and dedication expected for their research project, with students in all three cohorts expressing similar sentiments during the exit interviews when discussing things they would have liked to know before starting GEOP. For example, students from cohort 1 stated "*amount of time research takes and how committed you have to be*," and "*the amount of dedication it took for research*." A student from cohort 2 said, "*it was hard to work with research…. Because you'd have to retain some amount of hours per week*", and students from cohort 3 mentioned, "*wasn't expecting the rigor of the research to be as high*" and "*time commitment* [needed] to *research, …. didn't realize how much in the spring and summer*." The students reported that the research demanded more time and focus that they had expected and also experienced a steep learning curve for research, similar to that reported by the "novice" students in (Thiry et al., 2012). As one student from cohort 2 said, "*At first, I had no idea what remote sensing was, the equipment, and all the computer databases … all seemed really confusing, but once I understood what they were, and their role in everything, that boosted my confidence.*" In addition, some students found that research mentors had high expectations and would have liked to spend more time with their 4YU mentors.

In general, the students who developed interest in their topic reported positive research experiences, while the students who were not paired with a mentor of their choice or who were not interested in their topic reported decreased interest in research with time. For example, a student from cohort 2 mentioned, "*I wasn't interested in the cyclone research. Which is a part of why I didn't do ... I kind of got behind, because I wasn't motivated to do it*," while another student from the same cohort who worked with the same mentor commented,

> *I felt pretty committed, I got to work in the group that I really wanted to work in and really enjoyed the hurricane research, tropical cyclones. And I seemed to get along really well with* [mentor-name], *I'm able to understand what she's doing.*

Overall, the GEOP experience was impactful for the CC students, irrespective of whether they completed all requirements of the program. A student who did not continue the program beyond summer and is now employed in a geoscience-related career, aptly summarized the impact in an email correspondence to the academic mentor,

> *The GEO Program was a really great experience that opened the door to my academic passion. And even though I didn't stay as long as I would've liked, it prepared me to be a part of something bigger than myself… and my future.*

Major barriers in GEOP participation reported by students included outside work commitments, balancing research and coursework demands with personal issues, long time commitments for the year-long program, and high expectations by the 4YU mentors. Even though some of the other barriers described in Table 5 such as family and medical situations are not unique to the CC students, the impacts are exacerbated, particularly for non-traditional and/or under-represented students.

In addition to providing insights, the exit interviews also helped improve the Program and significant enhancements and changes were made, as detailed in Table 6. For example, a student in the first cohort mentioned "*...we need a little bit better background as to what they were researching in and the particular programs they were using beforehand*." In response, we matched the students with research mentors based on ranked prefences after the visit to 4YU in the subsequent years (see Table 6). Also, the improvements in the Commitment Forms were in response the comments from the students in the first cohort indicating the need to better articulate the time commitment required for the GEOP. Similarly, the students in the first year reported that they would have preferred to better understand their tasks and expec-

Table 5. *Summary of student responses regarding various aspects of the GEOP. In cases when multiple students provided similar responses, their number is given in the parenthesis. The anonymous, shuffled responses from the transcripts have been grouped by topics in the table.*

Topics		Cohort 1 (4 responses)	Cohort 2 (7 responses)	Cohort 3 (5 responses)
Overall Program	Most Valuable Part	• Internship (3); qualitative and quantitative research; communicating science information to general audience	• Internship (3); working with a research and/or SC mentors (3); cohort experience (2); meeting with geoscientists and field trips; courses; and research (4)	• Internship (3); field work; presenting at a professional conference (2) • All the experiences
	Skills Learned	• Improved understanding of geosciences (4) • On-the-job experience during internship; interacting and disseminating information; communication and literature review skills • Exposure to outreach and education	• Improved understanding of geosciences (7); First time exposure to geosciences (5) • Communication skills (3); persistence; research skills of dedication and prioritization; literature review • Realization of disinterests • Exposure to industry, 4YU, field work and education	• Improved understanding of geosciences (5); First time exposure to geosciences (2) • Changed major to geosciences • On-the-job experience (2); working with younger audience; public speaking; scientific presentation and Interview skills; GIS/ArcGIS skills; contacts and networking
	Suggested Improvements	• Improved organization and communication among institutions and mentors (4) • Improved flow of the Program • More regular and frequent meetings with the whole team • Financial clarification and disbursement of funds	• Improved organization (2) • Improved communication between student and 4YU mentor (3), among mentors (2); and tools • Clearer expectations (3) • More emotional support • Higher gender diversity (2) and larger cohort	• More committed and dedicated mentors • Improved mentor matching • Continued access to laptops beyond internship
Academic	Experience	• Provided exposure to geology and geoscience (4) • Learned a lot from CC mentors	• Phys geography was very helpful (2) • Learned a lot from CC mentors and staff (5) • CC mentors helped with time management, plan for graduate school, address research issues • Field trips and 4YU faculty coming and presenting in class was helpful	• CC mentor was very helpful and easy to talk to (5) • Honors advisor was helpful • CC mentor helped prepare poster presentation after hours
	Suggested Improvements	• More advanced topics in physical geography class specific to GEOP • More frequent visits from 4YU mentors	• Clarification regarding role of the honors mentor in GEOP • Improved organization and communication. • Suggest using group chats instead of Slack	
Research	Experience	• Increased interest in research over time • Higher than expected time commitment and involved tracking of research hours	• Committed in spring and summer (4), but in the fall not so much • Initially confused, later understood and developed confidence (2) • Enjoyed working on topic of choice • Dampened enthusiasm due to paper-work burden, resulting in no data collection • Limited mentor availability encouraged independence and actively seeking help • Not interested in the topic/mentor • Too technical, needed help from other cohort members	• Not committed in spring and summer, but more in fall after internship (2); preparation for conference presentation helped with motivation and ownership of research • More committed in spring than summer • Intimidated by research, technically challenging (2) • Not interested in the topic/mentor • Expected to do own research but was given steps to be followed. • Frustrating experience
	Suggested Improvements	• More time allocation by 4YU mentors for GEOP student • Increased personal connection with 4YU mentors	• More time allocation by 4YU mentor for GEOP student • Improved communication • Lower research expectation from 4YU mentors	• More time allocation by 4YU mentor for GEOP student • Improved communication, organization, and responsiveness • More help in resolving technically issues
Internship	Experience	• Best part of the Program • Very committed and involved • Research project was core of the demo • All SC mentors were connected	• Mentors were involved in all aspects • Students were involved (4) • Projects finished as scheduled • Increased confidence	• Most fun at a job • Students were involved (4) • Good work environment encouraging teamwork
	Suggested Improvements	• Clearer expectations	• Clearer expectations	• Clearer expectations
Overall Barriers		• Competing academic and research demands • Organizational and communication issues	• Financial stress due to delays in financial aid • Work commitment (2) • High time commitment for the entire duration • High expectations from research mentors; intimidated by the 4YU mentors (2) • Technically challenging • Personal family issues/medical problems (2) • Not matched with topic/mentor of interest (2) • Organizational and communication issues	• Full time job due to lack of financial aid • Long commute to 4YU (2) • Competing academic and research demands • High expectations from research mentors; communication issues with 4YU mentor; high time commitment for research • Not matched with topic/mentor of interest • Personal/health issues • No access to laptops after internship • Discouraged when felt behind in research

Table 6. *Enhancements and changes made to the GEOP during the second and third years.*

Recruitment and Retention	• GEOP alumni helped in recruiting. • Application and Commitment forms updated based upon first year experience and student feedback (Lannon et al., 2021) • Modified the eligibility to students unable to commit to the internship. • Concept of "alternate" student eliminated and up to 9 students could be admitted, with the best performers during the Spring semester filling 6 internship positions. • Monetary Program completion incentive of USD300, held from the internship stipend, was provided to the students at the end of the fall semester • The 4YU affiliation paperwork started immediately after acceptances in the Fall semester to provide students access to 4YU resources at the start of the Program in January. • Laptops provided on loan by the SC. • 20 G flash drives provided for data storage and transfer.
Academic	• The students enrolled in a section of the Physical Geography course that consisted only of GEOP students. • The spring Seminar course included more basic research-oriented topics, such as note-taking skills and using references and citations • Capstone course conducted in-person to incorporate increased participation in GEOP-related employment and workforce experiences.
Research	• Student-mentor matching made based upon student preferences after their visit to the 4YU once the students were aware of research projects and environments of each mentor • In-person or remote monthly project meetings for all the students and the core mentor for research progress including methods and expected outcomes • Paid peer mentors at 4YU assigned to the students to help familiarization with 4YU, answer research-related questions, increase their network, and help with vertical transfer. • Research requirement in the fall semester eliminated to increase participation in spring and summer research • Some flexibility in changing mentors/topics
Internship	• Several trips to SC in the spring to familiarize with the environment and staff prior to beginning their internship • Fund disbursement • Provided housing allowance at the beginning of the internship • Internship stipend provided biweekly • Students focused on communication in informal setting, on delivery, outreach, and audience interactions • A collaborative, hands-on experimental facility and a 3-D science animation presentation technology were included in content development and aided in facilitation • Second year cohort: • utilized 3-D animation for discussing greenhouse gases; hurricane seasons; reducing, reusing, and recycling; and sea-level rise • continued expansion of the teacher professional development kits started by the first year cohorts. • Third year cohort: • used the 3-D platform for touring outer space focusing on Moons and More. • completed the professional development kits and distributed to middle school science teachers during the fall and spring semesters after completion of the internship • Instead of attending the technology convention, the students delivered their summer projects at the SC working directly with the SC guests for one day in the fall semester, as culmination of their internship experience
Feedback and Evaluations	• SC requested summative evaluations via email regarding program design, experience, and potential improvements. The evaluations were conducted on a 5-point scale.
Communication (*among* mentors and between mentors and students)	• Slack channel and group chats • SC mentors included in monthly research meetings for smoother transition from course work and research to internship and back to coursework and presentations. • Semimonthly Program strategic discussion meetings conducted throughout the year.

tations during the internship prior to starting their experience at the SC. In response to this feedback, the SC mentors participated in the monthly group meetings in Years 2 and 3, rather than only getting introduced to students on their spring SC visits at the onset of the Program in January (See Table 6). In addition, the students visited and toured the SC facilities multiple times during the spring semester in Years 2 and 3.

Even though we successfully addressed many logistical issues encountered during the first year in the following years (see Table 6), flexibility was essential in successful implementation. We made several adjustments to accommodate students' unforeseen circumstances, their prior and ongoing commitments, financial hardships, and learning styles. For example, opening the eligibility to students who could not commit to the summer away from home due to other obligations helped at least two students finish other components successfully without requiring the internship. For the academic component, creating 0-credit option for the two new courses was immensely helpful for students with financial issues, with 16 out of 20 students using the option for the spring Seminar course and 11 using for the fall Capstone course. This was non-trivial, as exemplified by the Community College Undergraduate Research Initiative that reported cumbersome curriculum approval process and credit limit regulations as two of the major barriers to creating new courses, with most programs using modifications to existing courses (Hewlett, 2016). Creative solutions and flexibility by the core mentoring team and the CC administrators helped obtain necessary approvals and implement these in time for the GEOP. The courses had flexible, hybrid delivery with in-person and online components. In addition, GEOP was flexible to allow one student to join who had passed the Physical Geography course prior, while another student from cohort 2 was allowed to re-take the course in a subsequent semester as a second chance to pass the course, even though they were ineligible for the internship.

Flexibility in research was also critical to help retain and engage students. For example, one student from the first cohort participated in field-research in Iowa in early summer and completed GEOP research requirements later in the fall. Another two students who could not make a final research presentation at the Undergraduate Symposium as part of their research requirement, gained experience in presenting their research as part of the fall Capstone class for course credit. A student in the third cohort, who couldn't be paired with research mentor/topic of their choice, almost dropped out of the Program due to lack of structured mentoring and interest in the topic. Their preferred mentor took on the student mid-way through the program. Such flexibility in research mentoring allowed this student to complete the Program and successfully transfer to the 4YU.

As seen in Table 5, the students from all three cohorts

suggested improvements in overall Program organization and communication. Communication between the mentors and the students remained one of the hardest challenges to overcome during the Program. Throughout the Program, we undertook new initiatives and tried different means of communication to continually address these challenges, learning lessons along the way. In the second and third years, we held meetings which included the SC mentors twice every month for strategic decisions on recruitment, course syllabi, and overall Program implementation. In addition, we used multiple platforms to conduct meetings, obtain feedback, exchange documents, and keep everyone informed, partially due to institutional incompatibility. The mentors kept meeting notes on Google Drive, with programmatic documents exchanged through Dropbox. The Zoom teleconferencing software was used for remotely conducted meetings. Since the mentors did not want students sharing their personal phone numbers for texts due to privacy concerns, in addition to emails, the Program team started communicating via multiple channels in Slack, which does not require personal information and is available both for computers and smart phones. However, some students and mentors were not actively engaged in using the software. Some reasons could be lack of technology including smartphone access, technology fatigue, and/or different preferred communication channels by the mentors.

Additional Experiential Learning Opportunities. The Program provided research and academic experiences beyond GEOP requirements. For example, as mentioned earlier, one student seized an opportunity to participate in a NASA-funded project to conduct field work in Iowa in a community-wide remote sensing experiment, completed all aspects of the Program successfully, and is now enrolled at a 4YU in Engineering. Four students presented at regional or national conferences, beyond the requirements of the Program. One student won the best undergraduate poster for their GEOP research at the Southeastern Division of the American Association of Geographers (SEDAAG) meeting, received the Merle Prunty Award for the best undergraduate student in the Division, became the Chair of the undergraduate group affiliated with AAG, has been appointed as the student representative to the Executive Committee of SEDAAG, and has received McNair Scholarship through the US Department of Education for their undergraduate and graduate education at a 4YU. Two students also presented a poster from their GEOP research at SEDAAG. One student won second place at the CC's Undergraduate Research Symposium and received the prestigious Darrel Hess Community College Geography Scholarship from the AAG. The scholarship is based upon academic and scholastic excellence and demonstrated financial need, and only 2 awards are made annually. Two students co-authored refereed journal articles with their GEOP mentors (Judge et al., 2021; Matyas and VanSchoick, 2021).

During the fourth (no-cost-extension) year of the GEOP, six students participated in additional academic activities. The students consisted of two new recruits (one white male who was a Veteran funded through the GI Bill; and one Hispanic female who was a hurricane refugee from Puerto Rico), and two each from cohorts 2 and 3. During the spring semester, the students enrolled in Environmental Science or Physical Geography Course or Independent Study course. In these courses, they learned about geography and environmental issues in Peru, in preparation for a 10-day educational study abroad trip that included two faculty and the six students. During the trip, in addition to visiting Machu Pichu, they conducted field work for soil and environmental hydrology and bed load dynamics. They collected data to measure fluvial water velocity, sediment size, and infiltration down different terraces. Upon their return, they conducted statistical analyses and presented their results in class and at the Honors Symposium at the CC.

CONCLUSION

The GEOP provided year-long experiential, high-impact learning opportunities that helped lower barriers for vertical transfer to 4YU for twenty students at the CC. The number of students in the GEOP are similar to the number of students typically reported by other programs at CCs. For example, Charlevoix et al. (2021) reported 21 students recruited from over 20 CCs in their pre-REU internship program over the four years. The vertical transfer rate of 70% for the GEOP students is significantly higher than the national average of 25% (Hossler et al., 2012) and 13-19% for students at the CC during GEOP years (NCES, 2019). The transfer rate for STEM students is 16%, nationally (Van Noy and Zeidenberg, 2014) and the rate of 37.5% was reported by (Charlevoix et al., 2021). Institutionally, at the CC, the Program enabled significant improvements for the award management infrastructure and new course development procedures, directly addressing the lack of infrastructure at CC as one of the major challenges in implementing experiential learning, mentoring, and community building (NASEM 2016). The cohort building activities and peer-mentoring from 4YU (in the second and third years, as shown in Table 6 - Research) provided opportunities to address imposter syndrome, cultural divides, and other personal barriers typically reported for vertical transfer (Gasiewski et al., 2010; Olson and Labov, 2012).

Based on GEOP outcomes, some students were more engaged in the academic component, while others were more impacted by the internship and/or research. Academically, since the students were familiar with coursework expectations, the completion rate for the academic component was

very high. During the summer, despite the time commitment and the two-hour driving distance, most students considered the internship as the most valuable component. More than half the students finished the research component successfully, even though they found it to be the most challenging of the three components. Most students became increasingly engaged and reported increased comfort with research in the fall compared to the spring semester. Including peer mentors from 4YU in the second and third years also helped with research engagement for the CC students, while providing mentorship experience for the 4YU students. In addition, mentor-matching with respect to students' learning styles and mentor's mentoring styles turned out to be a more significant factor than the GEOP team had expected.

We offer several recommendations for future implementations based upon our experiences from the GEOP. First, communication among the mentors and between the mentors and the students is fundamental. Such communication remained a challenge in the GEOP even though many adjustments were made, and additional means of communication were incorporated. A Program Coordinator, who is not one of the mentors, could have resolved many of the communication and coordination issues successfully. Unfortunately, the GEOP could not afford a Coordinator due to funding constraints. Second, the one-year commitment, though beneficial for an immersive experience, presented recruitment and retention challenges in the GEOP. Some interested students were unable to apply due to scheduling issues and some participants could not finish all three components due to performance, personal and/or fiscal responsibilities. While, ideally, students should participate in all three components for a holistic experience and impact, flexibility in allowing the students to participate in the components they are able to, though not ideal, may resolve scheduling issues. In addition, local internship opportunities may help students who are unable to travel or stay away from home for an extended period. As also recommended in Matyas et al. (2022), financial compensation for research may allow students to reduce other employment and help increase recruitment and retention. Third, training of mentors, specifically for mentoring CC students (Clair, 1994; Lari and Barton, 2021), may help better understand the issues and challenges unique to the student population and strategies for addressing them. Finally, to avoid mentor burnout, the program may benefit from mentor rotation. This will also help introduce new topics for each cohort.

Overall, GEOP was highly successful in addressing barriers to recruitment, retention, and vertical transfer in STEM disciplines for CC students through a multi-faceted implementation combining course-based experiences with research and internship. We envision that STEM researchers and program designers will find many elements of GEOP transferable to their own work and the implementation, improvements, and recommendations presented here will provide guidance and structure to their programs.

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ABBREVIATIONS

4YU: 4-Year Universities; CC: Community College; GEOP: Geoscience Education and Outreach Program; NIH: National Institutes of Health; NSF: National Science Foundation; SC: Science Center; SEDAAG: Southeastern Division of the American Association of Geographers; STEM: Science, Technology, Engineering, and Math

REFERENCES

A. Long (Ed.). (2016). Overcoming educational racism in the community. Retrieved from https://orcid.org/0000-0002-0012-0032

AACC. (2021). Fast facts. Retrieved from https://www.aacc.nche.edu/research-trends/fast-facts/

Adelman, C. (2005). Moving into town-and moving on: The community college in the lives of traditional-age students. Wshington, D.C.

Beals, R., Zimny, S., Lyons, F., and Bobbitt, O. (2021). Activating social capital: how peer and socio-emotional mentoring facilitate resilience and success for community college students. Frontiers in Education, 6 (September), 1–16. https://doi.org/10.3389/feduc.2021.667869

Blake, R. A., Liou-Mark, J., and Chukuigwe, C. (2013). An effective model for enhancing underrepresented minority participation and success in geoscience undergraduate research. Journal of Geoscience Education, 61(4), 405–414. https://doi.org/10.5408/12-417.1

Bordes-Edgar, V., Arredondo, P., Kurpius, S. R., and Rund, J. (2011). A longitudinal analysis of Latina/o students' academic persistence. Journal of Hispanic Higher Education, 10(4), 358–368. https://doi.org/10.1177/1538192711423318

Byars-Winston, A. M., Branchaw, J., Pfund, C., Leverett, P., and Newton, J. (2015). Culturally diverse undergraduate researchers' academic outcomes and perceptions of their research mentoring relationships. International Journal of Science Education, 37(15), 2533–2554. https://doi.org/10.1080/09500693.2015.1085133

Carpi, A., Ronan, D. M., Falconer, H. M., and Lents, N. H. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. Journal of Research in Science Teaching, 54 (2), 169–194. https://doi.org/10.1002/tea.21341

Charlevoix, D. J., Morris, A. R., Russo-Nixon, K., and Thiry, H. (2021). Engaging two-year college students in geoscience: Summer Pre-REU internships and professional development to prepare students for participation in research. Journal of Geoscience Education, 0 (0), 1–16. https://doi.org/10.1080/10899995.2021.1977770

Clair, K. L. St. (1994). Faculty-to-faculty mentoring in the community college: an instructional component of faculty development. Community College Review, 22(3), 23–35. https://doi.org/10.1177/009155219402200304

Cohen, A. M., Brawer, F. B., and Kisker, C. B. (2014). The American Community College. San Francisco, CA: Jossey-Bass.

Cooper, J., Jabanoski, K., and Kaplan, M. (2019). Exploring experiential opportunity impacts on undergraduate outcomes in the geosciences. Journal of Geoscience Education, 67 (3), 249–265. https://doi.org/10.1080/10899995.2019.1581394

Coyle, E. J., Krogmeier, J. V., Abler, R. T., Johnson, A., Marshall, S., and Gilchrist, B. E. (2016). The Vertically Integrated Projects (VIP) Program: Leveraging faculty research interests to transform undergraduate STEM education. In G. . Weaver, W. D. Burgess, A. L. Childress, and L. Slakey (Eds.), Transforming Institutions: undergraduate STEM education for the 21st Century (pp. 223–234). West Lafayett, IN: Purdue University Press.

Crisp, G. (2010). The impact of mentoring on the success of community college students. The Review of Higher Education, 34(1), 39–60.

Deek, F., Briller, V., Friedman, R., and Joshi, K. (2003). Active research experience for undergraduates increases students' motivation and academic performance. ASEE Annual Conference and Exposition, 8.161.1-8.161.18. Retrieved from https://peer.asee.org/12353

Eagan, M. K., Hurtado, S., Chang, M. J., Garcia, G. A., Herrera, F. A., and Garibay, J. C. (2013). Making a difference in science education: The impact of undergraduate research programs students' intentions to enroll in STEM and non-STEM graduate and professional programs. In Am Educ Res J (Vol. 50). https://doi.org/10.3102/0002831213482038. Making

Fechheimer, M., Webber, K., and Kleiber, P. B. (2011). How well do undergraduate research programs promote engagement and success of students? CBE Life Sciences Education, 10(2), 156–163. https://doi.org/10.1187/cbe.10-10-0130

Gasiewski, J., Tran, M. C., Herrera, F. A., Garcia, G. A., and Newman, C. B. (2010). Barricades, bridges, and programmatic adaptations: A multi-campus study of STEM undergraduate research programs. Association for Institandtional Research Annual Meeting. Chicago, IL.

Ginder, S., Kelly-Reid, J. E., and Mann, F. B. (2015). Enrollment and employees in postsecondary institutions, fall 2014; and financial statistics and academic libraries, fiscal year 2014 (NCES 2016-005). Washington, D.C.: National Center for Education Statistics.

Graham, C. R., Woodfield, W., and Harrison, J. B. (2013). A framework for institutional adoption and implementation of blended learning in higher education. The Internet and Higher Education, 18, 4–14. https://doi.org/https://doi.org/10.1016/j.iheduc.2012.09.003

Hagedorn, L. S., and DuBray, D. (2010). Math and science success and nonsuccess: Journeys within the community college. Journal of Women and Minorities in Science and Engineering, 16 (1), 31–50.

Handel, S. (2013). Recurring trends and persistent themes: A brief history of transfer. A report for the initiative on transfer policy and practice. New York, NY.

Hewlett, J. A. (2016). Undergraduate research at the community college: Barriers and opportunities. In ACS Symposium Series: Vol. 1231. The Power and Promise of Early Research (pp. 137-151 SE – 8). https://doi.org/doi:10.1021/bk-2016-1231.ch008

Hossler, D., Shapiro, D., Dundar, A., Ziskin, M., Chen, J., Zerquera, D., and Torres, V. (2012). Transfer and mobility: A national view of pre-degree student movement in postsecondary institutions (Signature Report No. 2). Herndon, VA.

Hunter, A.-B., Laursen, S. L., and Seymour, E. (2007). Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development. Science Education, 91 (1), 36–74. https://doi.org/https://doi.org/10.1002/sce.20173

Jin, L., Doser, D., Lougheed, V., Walsh, E. J., Hamdan, L., Zarei, M., and Corral, G. (2019). Experiential learning and close mentoring improve recruitment and retention in the undergraduate environmental science program at an Hispanic-serving institution. Journal of Geoscience Education, 67 (4), 384–399. https://doi.org/10.1080/10899995.2019.1646072

Judge, J., Liu, P. W., Monsivais-Huertero, A., Chakrabarti, S., Bongiovanni, T., Steele-Dunne, S., … Cosh, M. J. (2021). Impact of vegetation water content information on soil moisture retrievals in agricultural regions. An analysis based on the SMAPVEX16-MicroWEX dataset. Remote Sensing of Environment, 265, 112623, doi:10.1016/j.rse.2021.112623

Kahan, D. M. (2012). Cultural cognition as a conception of the cultural theory of risk. In S. Roeser (Ed.), Handbook of risk theory (pp. 725–759). Springer Netherlands.

Karp, M. M. (2011). Toward a new understanding of non-academic student support : Four mechanisms encouraging positive student outcomes in the community college. CCRC Working Paper, (February), 42. Retrieved from http://ezproxy.library.wisc.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED516148&login.asp&site=ehost-live

Krim, J. S., Coté, L. E., Schwartz, R. S., Stone, E. M., Cleeves, J. J., Barry, K. J., … Rebar, B. M. (2019). Models and impacts of science research experiences: A review of the literature of cures, ures, and tres. CBE Life Sciences Education, 18(4), 1–14. https://doi.org/10.1187/cbe.19-03-0069

Laanan, F. S., Starobin, S. S., and Eggleston, L. E. (2010). Adjustment of community college students at a four-year university: role and relevance of transfer student capital for student retention. Journal of College Student Retention: Research, Theory and Practice, 12 (2), 175–209. https://doi.org/10.2190/CS.12.2.d

Lannon, H. J. L., Stofer, K., Matyas, C., and Judge, J. (2021). Supplementary documents on Open Science Framework. Retrieved from Website website: https://osf.io/apbnv/?view_only=0f1a28ffb072479bba3ab98f3883d721

Lari, P., and Barton, D. H. (2021). Building Communities of Practice Through Faculty Mentorship Programs. In Research Anthology on Facilitating New Educational Practices Through Communities of Learning (pp. 18–31). https://doi.org/10.4018/978-1-7998-7294-8.ch002

Lee, V. E., and Frank, K. A. (1990). Students' characteristics that facilitate the transfer from two-year to four-year colleges. Sociology of Education, 63 (3), 178–193. https://doi.org/10.2307/2112836

Libarkin, J. C., and Anderson, S. W. (2005). Assessment of learning in entry-level geoscience courses: Results from the geoscience concept inventory. Journal of Geoscience Education, 53 (4), 394–401. https://doi.org/10.5408/1089-9995-53.4.394

Linn, M.C., Palmer, E., Baranger, A., Gerard, E., and Stone, E. (2015). Undergraduate research experiences: Impacts and opportunities. Science, 347(6222), 627–633. https://doi.org/10.1126/science.1261757

Linn, Marcia C., Palmer, E., Baranger, A., Gerard, E., and Stone, E. (2015). Undergraduate research experiences: Impacts and opportunities. Science, 347(6222). https://doi.org/10.1126/science.1261757

Lopatto, D. (2004). Survey of undergraduate research experiences (SURE): First finding. CBE Life Sciences Education, 9 (3), 270–277. https://doi.org/10.1187/cbe.04-07-0045

Matyas, C. J., and VanSchoick, S. (2021). Geospatial analysis of rain fields and associated environmental conditions for cyclones Eline and Hudah. Geomatics, Vol. 1. https://doi.org/10.3390/geomatics1010008

Matyas, C., Stofer, K. A., Lannon, H. J. L., Judge, J., Hom, B., Lanman, B., and Norton, H. (2022). Despite challenges, two-year college students benefit from but face unique obstacles to undergraduate geoscience research at a 4-year university during an extracurricular program. Journal of Geoscience Education, DOI:10.1080/10899995.2022.2037403

Monaghan, D. B., and Attewell, P. (2015). The community college route to the Bachelor's degree. Educational Evaluation and Policy Analysis, 37 (1), 70–91. https://doi.org/10.3102/0162373714521865

Nagda, B. A., Gregerman, S. R., Jonides, J., Von Hippel, W., and Lerner, J. S. (1998). Undergraduate student-faculty research partnerships affect student retention. Review of Higher Education, 22 (1), 55–72. https://doi.org/10.1353/rhe.1998.0016

National Academy of Sciences, Engineering, and Medicine. [NASEM]. (2011). Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads. https://doi.org/10.17226/12984

National Academies, of Sciences, Engineering, and Medicine. [NASEM]. (2016). Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways (S. Malcom and M. Feder, Eds.). https://doi.org/10.17226/21739

National Academies of Sciences, Engineering, and Medicine [NASEM]. (2017). Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities (J. Gentile, K. Brenner, and A. Stephens, Eds.). https://doi.org/10.17226/24622

National Center for Education Statistics. (2019). Integrated postsecondary education data system (IPEDS) data feedback report. Retrieved from https://nces.ed.gov/ipeds

National Student Clearinghouse Research Center. (2017). Contribution of two-year public institutions to bachelor's completions at four-year institutions. Retrieved from http://research.studentclearinghouse.org

Olson, S., and Labov, J. B. (2012). Community colleges in the evolving STEM education landscape: Summary of a summit. In Community Colleges in the Evolving STEM Education Landscape: Summary of a Summit. https://doi.org/10.17226/13399

Paglis, L. L., Green, S. G., and Bauer, T. N. (2006). Does adviser mentoring add value? A longitudinal study of mentoring and doctoral student outcomes. Research in Higher Education, 47 (4), 451–476. https://doi.org/10.1007/s11162-005-9003-2

Pallant, A., McIntyre, C., and Stephens, A. L. (2016). Transforming undergraduate research opportunities using telepresence. Journal of Geoscience Education, 64 (2), 138–146.

Rodenbusch, S. E., Hernandez, P. R., Simmons, S. L., and Dolan, E. L. (2016). Early engagement in course-based research increases graduation rates and completion of science, engineering, and mathematics degrees. CBE Life Sciences Education, 15, 1–10. https://doi.org/10.1187/cbe.16-03-0117

Sadler, T. D., Burgin, S., McKinney, L., and Ponjuan, L. (2010). Learning science through research apprenticeships: A critical review of the literature. Journal of Research in Science Teaching, 47 (3), 235–256. https://doi.org/https://doi.org/10.1002/tea.20326

Seymour, E., Hunter, A.-B., Laursen, S. L., and DeAntoni, T. (2004). Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. Science Education, 88(4), 493–534. https://doi.org/https://doi.org/10.1002/sce.10131

Shapiro, D., Dundar, A., Wakhungu, P. K., Yuan, X., Nathan, A., and Hwang, Y. (2016). Completing college: A national view of student attainment rates - Fall 2010 cohort (Signature Report No. 12). Retrieved from https://nscresearchcenter.org/signaturereport12/

Shapiro, Doug, Dundar, A., Huie, F., Wakhungu, P. K., Yuan, X., Nathan, A., and Hwang, Y. (2017). Tracking transfer: Measure of effectiveness in helping community college students to complete Bachelor's degrees. Retrieved from www.luminafoundation.org.

Singer, J., and Zimmerman, B. (2012). Evaluating a summer undergraduate research program: Measuring student outcomes and program impact. Council on Undergraduate Research Quarterly, 32(3), 40–47.

Snyder, T. D., de Brey, C., and Dillow, S. A. (2019). Digest of Education Statistics. In National Center for Education Statistics (Publicatio). Retrieved from https://nces.ed.gov/fastfacts/display.asp?id=16

Stofer, K., Insalaco, S., Matyas, C., Lannon, H. J., Judge, J., Lanman, B., … Norton, H. (2021). Two-year college students report multiple benefits from participation in an integrated geoscience research, coursework, and outreach internship program. Community College Review, 49(4), pp 457-482, doi:10.1177/00915521211026682

Storksdieck, M., Stylinski, C., and Nicolette, C. (2017). The Impact of Portal to the Public: Creating an Infrastructure for Engaging Scientists in IS: Summative Evaluation. Retrieved from https://ir.library.oregonstate.edu/concern/technical_reports/dv140102j

Thiry, H., Weston, T. J., Laursen, S. L., and Hunter, A. B. (2012). The benefits of multi-year research experiences: Differences in novice and experienced students' reported gains from undergraduate research. CBE Life Sciences Education, 11(3), 260–272. https://doi.org/10.1187/cbe.11-11-0098

Tovar, E. (2013). A Conceptual Model on the Impact of Mattering, Sense of Belonging, Engagement/Involvement, and Socio-Academic Integrative Experiences on Community College Students' Intent to Persist. CGU Theses and Dissertation, (1–336). https://doi.org/10.5642/cguetd/81

Trott, C, D., Sample McMeeking, L. B., Bowker, C. L., and Boyd, K. J. (2020). Exploring the long-term academic and career impacts of undergraduate research in geoscience: A case study. Journal of Geoscience Education, 68 (1), 65–79. https://doi.org/10.1080/10899995.2019.1591146

Van Noy, M., and Zeidenberg, M. (2014). Hidden STEM producers: Community colleges ' multiple contributions to STEM education and workforce development. https://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_088831.pdf

Walkington, H., Stewart, K. A., Hall, E. E., Ackley, E., and Shanahan, J. O. (2020). Salient practices of award-winning undergraduate research mentors–balancing freedom and control to achieve excellence. Studies in Higher Education, 45 (7), 1519–1532. https://doi.org/10.1080/03075079.2019.1637838

Wolfe, B. A., and Rigges, E. M. (2017). Macrosystem analysis or programs and strategies to increase underrepresented populations in Geosciences. Journal of Geoscience Education, 65 (4), 577–593. https://doi.org/10.5408/17-256.1

Wolfe, T. (2013). Investigating science identity and motivation constructs in undergraduate chemistry through novel instrument development. Oregon State University.