ASSESSMENT

# Impact of Short-Duration Research Experiences on STEM Self-Efficacy among Early-Stage, Rural, First-Generation College Students

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## Abstract

First-generation college students without broad support networks are more likely to leave STEM majors. In rural West Virginia, the First2 Network aims to improve STEM persistence by including students in creating solutions to STEM attrition. One solution, a research program for rising first-year students in STEM majors, is discussed here. The authors assessed students' STEM education and career plans, identity, efficacy, and sense of school of belonging before and after the program. Intern and faculty perspectives were also analyzed. Students' STEM identity, efficacy, and school belonging improved after participation. However, First2 students' early STEM persistence rates were lower than state rates for somewhat similar non-First2 students.

**Keywords:** *early undergraduate research, first-generation students, high school students, retention, self-efficacy, STEM*

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First-generation college students majoring in science, technology, engineering, and mathematics (STEM) disciplines face considerable obstacles to their college success (Chen 2013), and attrition from STEM majors is most likely to occur during students' first two years of college (Olson and Riordan 2012). Accurate estimates of how many West Virginia students could be characterized as first generation—students whose parents did not earn a four-year undergraduate degree—are difficult to obtain. However, given that fully 70 percent of adults in the state do not have a postsecondary degree (Lounsbury and Datubo-Brown 2019), many West Virginia STEM students matriculating in college are likely to be the first in their families to attend. The First2 Network is a West Virginia alliance established to address this problem and improve the early persistence of rural, first-generation STEM students in their majors.

The First2 Network ("First2") is a five-year and $7.15 million grant from the NSF INCLUDES initiative, which funds efforts to broaden the participation of underrepresented groups in STEM education and careers (National Science Foundation 2020). First2 facilitates collaboration among university STEM faculty; rural, first-generation STEM undergraduates; National Laboratory STEM professionals; K–12 educators; informal STEM educators; industry representatives; and others to study and address the problem of undergraduate attrition in STEM majors that occurs during the first two years of college.

First2 operates in a particular context. West Virginia is a rural state within the socioeconomically depressed

central region of Appalachia. In fact, more than 50 percent of students attending public high school receive free- or reduced-priced lunches (High-Schools.com 2020). West Virginia high school students live in small rural communities, attend small high schools (662 average size; 1914 largest size; (Public School Review 2020), and are likely to lack familial awareness of state and national opportunities. West Virginia does offer its own statewide opportunities for STEM engagement, such as the Governor's Schools in STEM and the Governor's Honors Academy (West Virginia Department of Education n.d.). However, the number of students served by these opportunities is limited, and only the highest-performing students are recommended for participation by their high schools. Lack of familial awareness of college—including navigating the college search, application, and admissions processes—are a defining feature of students who are first-generation college attendees. First-generation students are behind in terms of college as early as elementary school. For example, in 2011, the West Virginia Higher Education Policy Commission found that only 26 percent of first-generation college students were thinking about college in elementary school compared to 53 percent of their non–first-generation peers (Noland 2011). Likewise, West Virginia's first-generation high school students were found to be less prepared for college. For example, they took fewer college prep courses (48 percent first-generation versus 72 percent non–first-generation), earned lower ACT scores, took fewer math courses and had lower grades in high school, and enrolled in college at lower rates (73 percent versus 90 percent; Noland 2011).

To achieve its aim of increasing persistence rates among rural, first-generation college students in the STEM disciplines, First2 has adopted a *collective impact* approach (Kania and Kramer 2011), in which a backbone organization brings together people, programs, education and community institutions, technologies, and industry to achieve results at scale. First2 also employs *improvement science* (Bryk et al. 2015; Lewis 2015), "a problem-solving approach centered on continuous inquiry and learning [in which c]hange ideas are tested in rapid cycles, resulting in efficient and useful feedback to inform system improvements" (REL West 2017, 1). Using these two approaches, the First2 Network assists its members across various sites to test strategies for improving early STEM persistence—including the research immersion program for rising first-year students discussed in this article.

First2 engages its more than 280 members in key activities such as the following:

- Establishing working groups to devise, test, and iteratively improve upon practices intended to increase early STEM persistence—such as the research immersion program.
- Championing and promoting student leadership to contribute to improvement practices based on students' own experiences of STEM preparation, college transition, and early STEM experiences in college.
- Co-creating with student leaders and testing a variety of student supports, including campus clubs for rural, first-generation STEM students; summer research immersion experiences; research internships during the academic year; and instruction in STEM skills development through a discovery-based seminar on the principles of research and development
- Creating a STEM ambassador program to prepare students to engage secondary students in STEM in their home communities and to harness support for STEM education from teachers and school board members.
- Disseminating evaluation and research findings to stakeholders across West Virginia
- Planning for First2 growth and long-term sustainability.

Engaging undergraduates in authentic research allows students to find their niche within STEM, ultimately enabling them to advance through upper-level STEM coursework and their chosen STEM career. However, few research opportunities exist for rising first-year students in the summer prior to their first semester of college. For instance, NSF-funded Research Experiences for Undergraduates (REU) sites primarily target rising second-year students through rising fourth-year students. Summer sites that do engage rising first-year students in research, networking, and cohort building are limited, aimed at achieving success in upper-level classes, extremely competitive, and may not be accessible to most students in West Virginia.

One key activity facilitated by First2 is a two-week summer immersion during which students ("interns") participate in research projects. West Virginia institutions and organizations submit proposals to First2 to obtain funding to host a summer immersion site. If funded, institutions must agree to participate in First2's ongoing research at the institutional level involving first-year STEM classes and persistence rates of first-generation college students. Recruitment, application, and planning are joint activities involving the leads from all sites and facilitated by First2. Each summer immersion site has a different capacity for participants, but typical numbers are 6–12 rising first-year students per site. In addition, advanced undergraduates are recruited to apply for positions as near-peer mentors ("mentors") and activity planners for each site (approximately two per internship site). Mentors are student leaders in First2, and most have participated in a summer immersion site previously. Mentors collaborated with site leaders on planning, executing, and assessing the immersion experience. Each site, through engagement with mentors, has a different schedule and set of activities intended to engage interns in STEM (see Richards-Babb n.d.).

In addition, mentors facilitate the research projects, live in the dorms with the participants, communicate with program administrators and researchers, and lead all group activities. The funding allows first-generation students, especially those from economically disadvantaged backgrounds, to participate. Mentors and interns receive competitive stipends, and all costs associated with participation (such as lodging, meals, and activity fees) are covered. In addition, a small amount of funding is available for purchase of research supplies and for payment of stipends to research project leaders (such as graduate students or faculty members).

Interns spend much of the two weeks engaged in STEM research overseen by STEM faculty, with the remainder devoted to social engagement, mentoring by advanced STEM majors, academic and professional development, career exploration, cohort building, and collegiate integration. Most important, the interns begin their journey by building their sense of STEM efficacy and agency, and by becoming advocates themselves and for other first-generation peers. Beyond the summer program, interns remain engaged by continuing to conduct STEM research, participating in leadership development opportunities, and providing input about the First2 Network change ideas and plans for sustainability. Engagement in this experience is expected to improve persistence of interns in their first two years of college in STEM disciplines, providing the next generation of STEM leaders and professionals for economic growth.

## Methods

In summer 2019, immersion sites were funded at four West Virginia institutions: Fairmont State University (FSU), Marshall University (MU), West Virginia State University (WVSU), and West Virginia University (WVU). The FSU site coordinated with the West Virginia branch of Chemours™, a local chemical company. The FSU-Chemours™ site provided its interns with one week of onsite exposure to careers in industry. A total of 79 students in their last year of high school applied to the four immersion sites. Applicants ranked their interest in engaging in research at each of the four sites ("high interest" = 2; "interest" = 1; "not interested" = 0). All applicants were reviewed with due attention to their first-generation status (as determined by parents' educational level), rurality, expected major, and overall application. Thirty-one intern positions were available and awarded, and engagement and persistence were assessed as described below.

Four methods were used to explore the effect of First2's short-duration research experiences on rural, first-generation STEM students and researchers:

1. Pretest and posttest surveys of interns' experiences
2. Intern focus groups conducted nine months post-immersion
3. Tracking of STEM persistence rates among interns
4. Qualitative faculty perspectives

### *Intern Survey*

The external evaluation team administered a survey to interns before and after their participation in the 2019 immersive research experiences. The survey included five subscales adapted from extant instruments:

1. STEM Career Certainty: Assesses how sure interns are about pursuing STEM education and career (Woodcock, Hernandez, and Schultz 2016)
2. STEM Efficacy: Measures interns' expectations about their performance in STEM courses (Chemers et al. 2011)
3. School Belonging: Assesses the extent to which students think they will feel connected to their college (Pintrich and De Groot 1990)
4. STEM Identity: Gauges interns' sense of themselves as people who are engaged with STEM (Chemers et. al. 2011)
5. STEM Plans: Assesses interns' plans to pursue STEM education and career (Chemers et. al. 2011)

### *Focus Groups*

A member of the external evaluation team conducted four focus groups in April 2020. Participants were interns from four universities that facilitated summer immersions in 2019. The 90-minute focus groups included discussion of the students' immersion experiences and reflection on the influence of such experiences on their decision to declare or not declare a STEM major, confidence in their ability to do STEM coursework, and sense of STEM identity. Interns were also asked how, if at all, the immersion continued to influence progress through their STEM majors.

### *STEM Persistence Rates*

Intern progress, including re-enrollment in the next semester and in a STEM major, was tracked throughout the academic year by the external evaluation team. The early persistence rate was calculated as the percent of interns who re-enrolled in a STEM major in fall 2020.

### *Faculty Perspectives*

Several authors of this article solicited faculty mentor perceptions via informal discussions and formal meetings among site coordinators and faculty mentors involved with the immersion program. Comments were compiled, de-identified, and analyzed thematically to understand faculty perspectives about, and suggestions for improvement of, the internships.

## Results

### *2019 Pretest–Posttest Survey*

A total of 25 interns (aged 18 or older) completed a pretest, and 25 completed a posttest. More than half of the

**TABLE 1. 2019 Intern Survey Results for STEM Subscales**

| Subscale | N | Pretest mean | Pretest SD | Posttest mean | Posttest SD | Mean difference |
|---|---|---|---|---|---|---|
| STEM Career | 25 | 3.88 | 0.52 | 3.94 | 0.58 | 0.06 |
| STEM Efficacy | 24 | 3.99 | 0.55 | 4.27 | 0.49 | 0.28[a] |
| School Belonging | 23 | 3.93 | 0.53 | 4.52 | 0.57 | 0.59[a] |
| STEM Identity | 23 | 3.78 | 0.63 | 4.17 | 0.72 | 0.39[a] |
| STEM Plans | 23 | 4.43 | 0.66 | 4.65 | 0.44 | 0.22 |

*Note:* Analysis conducted through matched pair *t*-tests.
[a]Statistically significant at the 0.05 level.

respondents were female (56 percent), and about two-thirds described themselves as white (67 percent). In addition, 35 percent indicated they qualified for a federal Pell Grant, 96 percent identified themselves as first-generation students, and more than three-fourths indicated they grew up in a town (48 percent) or a rural area (35 percent). The most frequently cited major among interns was biology (44 percent).

Matched pair *t*-test results are shown in Table 1 for the five subscales of STEM Career, STEM Efficacy, School Belonging, STEM Identity, and STEM Plans. Interns rated the STEM Plans subscale the highest, at pretest and posttest (4.43 and 4.65, respectively, on a 5-point scale). They rated STEM Identity the lowest at pretest (3.78); at posttest, they rated STEM Career the lowest (3.94). Interns had higher scores at posttest for each of the five areas, with improvements on the STEM Efficacy, School Belonging, and STEM Identity subscales achieving statistical significance.

### *Focus Groups*

A total of 23 interns participated across four focus groups conducted in April 2020. Most participants were first-generation college students, came from rural backgrounds, and had declared STEM majors. Two interns were unsure about their status, and one intern did not identify as a first-generation college attendee. Further, one intern was not a STEM major but had a STEM minor. Three interns arrived late to their focus groups, and demographic information was not obtained from them. Results are summarized in Table 2.

Interns were asked how participation in the research immersions affected their decisions about a STEM major. Although interns selected for the program had already declared their STEM major, they indicated that the immersion experience helped them identify contacts within their major, strengthened their desire for a particular STEM major, opened their eyes to new areas of interest within their STEM majors, and provided insights about the array of STEM fields and research within those fields. A few reported that the immersion did influence their decisions related to a STEM major. Only one intern said that the immersion had no influence on the decision to study STEM.

Interns also indicated that the immersions had influenced their confidence to do STEM coursework. Some noted it helped them know what to expect in some of their classes, gain some experience in doing those activities, and increase their confidence in their research topics. Others focused on learning how to work in a laboratory setting, forming relationships with advanced undergraduates and faculty members that they could go to later for help with their coursework, and increasing their confidence to do presentations. As one intern put it, "I wasn't really confident in myself, so I wasn't 100% sure if I wanted to go to college yet, so the summer immersion was like . . . a confidence booster for me. . . . That was the thing that made me decide I can do this and I'm going to do this."

Several interns provided comments about the immersion's influence on their sense of themselves as future scientists or mathematicians. One noted, "With the math project, we actually worked on a real problem for a company, and so I think that helped me see a different side of math. I got to see a different side of where math and science could take you." Another shared a similar perspective: "I got insight to see what it was really like doing research in a lab as a scientist because we did get to tour several labs in the chemistry department while we were there."

Interns reported that the immersion had influenced progress through their STEM majors in various ways. For example, one student said that experience with computer programming during the immersion prepared her for a programming class that she completed successfully during her first college semester. Another described how one of the immersion faculty became this student's professor, "so I wasn't scared to go to his office because I knew him personally." A third intern reported that the immersion "allowed me to connect with a professor and I was able to do more research and actually be a part of other research opportunities such as making a light device for his lab."

**TABLE 2. 2019 Intern Focus Group Findings**

| |
|---|
| Most interns had already selected a STEM major prior to participation in the summer immersion program. |
| Most interns also indicated that the summer program had influenced their confidence, or sense of efficacy, to do STEM coursework in a college environment. |
| Some interns reported that the summer program had facilitated their sense of themselves as future scientists, engineers, or mathematicians. |
| Most interns reported that the summer program influenced their persistence in a variety of ways—through exposure to relevant content they could apply in their coursework, new faculty relationships, and/or access to other research opportunities. |
| Other themes not reported in the text of this article include gauging student appreciation for experiencing campus life before the fall semester; building relationships with other rural, first-generation STEM students; and gaining insight into the experience of conducting STEM research. |

In sum, focus-group data tended to confirm data from the intern survey. In other words, both survey and focus-group data suggest that the immersion had little influence on decisions to pursue a STEM major, but that it did enhance interns' sense of STEM efficacy and identity.

### *STEM Persistence Rates*

Four of the 31 2019 interns could not be contacted to confirm fall-to-fall STEM re-enrollment; these cases were treated as missing data. Of the 27 remaining interns, 19 persisted in a STEM major between the fall 2019 and fall 2020 semesters, for an early STEM persistence rate of 70 percent. Seven interns, or 26 percent, did not re-enroll in a STEM major in fall 2020: five left college; two switched to other majors—one to cyber forensics and one to business. Thus, the findings are not wholly disheartening, because three of the eight students who did not re-enroll in STEM nonetheless persisted in college, resulting in a total early college persistence rate of 78 percent. In addition, one student (3 percent) dropped out of college for personal reasons but expressed a clear intention to return the following semester.

One comparison that can be made is to the West Virginia rate of fall-to-fall re-enrollment in a STEM major amongst rural STEM students eligible for a Pell Grant (a proxy for first-generation status, since the West Virginia Higher Education Policy Commission does not collect this information), which was 74 percent amongst first-year students in 2018. Thus, the 2019 First2 intern early STEM persistence rate of 70 percent is lower than that of somewhat similar students statewide.

### *Faculty Perspectives*

Faculty view immersive experiences at such an early stage of students' postsecondary education with mixed opinions. In the short term, faculty expressed concern about the immersion program's significant time and financial commitments. However, they also thought that successful internship experiences and training pay significant dividends in the long term, because students can spend years in a lab advancing research areas and supporting faculty interests.

The immersive experiences of academically young students require a significant time commitment for the faculty members both to organize the program and train students before they have knowledge of experimental procedures and relevant theoretical concepts. Novice researchers are more prone to have accidents in the laboratory that include spills, broken equipment, additional reagents, and low-yielding reactions. This time commitment comes in many forms, including significant monitoring due to the safety risks involved with hosting interns in laboratories that are designed to push the boundaries of scientific understanding. The increased amount of time monitoring and teaching these interns has required a rescheduling of faculty time, which can interfere with other duties.

However, the faculty tended to agree that the rewards for this program are more long term in nature and vastly exceed the investments required to train students. Once an intern becomes trained to conduct basic research tasks, laboratory efficiency improves. The increased time commitment to train a new intern during the first year (beyond the two-week immersion program) can lead to three productive years as the intern becomes more familiar with protocols and more comfortable with handling reagents. Most important, in addition to being researchers, faculty are also educators. This immersion program provides a mechanism to support the educational attainment of students as well as a direct pathway to support students pursuing STEM degrees.

## Discussion

The summer immersion program sought to fulfill many objectives. The program achieved its aims of increasing intern STEM efficacy, school belonging, and STEM identity; on the other hand, the program did not appear to

alter interns' STEM educational or career plans. However, interns' early STEM persistence rates were lower than those of similar first-year students who did not participate. Overall, the program achieved some of its aims but not yet its primary goal.

Focus group results suggest that First2 Network participation, and not simply participation in the summer research experiences, contributed to maintaining students' sense of school belonging and STEM identity. For instance, First2 established campus clubs for first-generation STEM students, whose members include interns and mentors from the various sites, as well as other students. These clubs continued First2 Network activities to encourage development of community amongst students and provide professional development opportunities. For example, one professional development opportunity was a "Meet the Professor" series, during which club members met, in an informal setting, faculty they are likely to encounter early in their studies in "lecture" courses. This enabled first-year students to become familiar with faculty and potential mentors early in their college careers. Another professional development topic discussed in the clubs was developing, maintaining, or expanding habits of health and wellness, enabling students to weather the inevitable stresses of college and life.

Perseverance is most difficult in the first two years of a STEM major. As suggested above, many forces can deter students from continuing their postsecondary careers. One of the most noticeable consequences of the two-week immersion program is the persistence of friendships initiated during this short period. Students require the support of their closest friend network quite often in the first few months of college, since personal, financial, and academic crises often come to a head near midterm. Although the first two years are critical, the first few months of the first semester may be even more critical. Without the support of their social group, even students with high ability can lose sufficient motivation to succeed during that first crucial semester.

The 2019 First2 immersion program engaged only a small cohort, but early findings indicate that students felt a stronger sense of STEM efficacy, school belonging, and STEM identity after their participation in summer research experiences. Such improved dispositions, however, do not appear to have translated into stronger early STEM persistence rates. First2 again offered immersion experiences in summer 2020, increasing both the number of sites and intern positions available to nine and 100, respectively, and transitioned to an online format due to the COVID-19 pandemic. Although it is not possible to explore findings from this experience here, the researchers anticipate publishing articles about what was learned from operating the program under such circumstances. In addition, the researchers will continue to investigate how to improve the early STEM persistence of rural, first-generation college students. First2, after all, is about *learning* how to help underrepresented students undertake difficult STEM coursework.

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