Overview

Improvement Science as a Mechanism to Accelerate Change Across a Regional Network

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Abstract: The First2 Network is a National Science Foundation-funded Networked Improvement Community (NIC) that engages nine higher education institutions in improvement science activities to improve the success of undergraduate STEM students in West Virginia and beyond. The aim of First2 Network is to double the graduation rate for rural, first-generation, and low-income STEM students, by changing systems within higher education.

In place since 2018, the First2 Network is essentially a learning community that consists of institutionally focused campus teams that test high impact practices on campus designed to address systemic barriers to success. Campuses measure progress through student survey responses and tracked student persistence numbers at their institutions. For students who have engaged in First2 Network change ideas, persistence has increased to upwards of 60% across the institutions in our program. We describe the working structure of our network as an introduction to this special edition of the PWVAS. Change ideas centered on improving STEM student belonging are the focus of this special edition.

Keywords: STEM student success; belonging; improvement science.

Introduction

The First2 Network is a two-state Networked Improvement Community that engages nine higher education institutions in West Virginia and Kentucky and partners with 30 other groups including non-profit organizations, state and federal government, and industry. One third of our members are first-generation, rural or low-income STEM students. Funded by the National Science Foundation INCLUDES program since 2018, First2 Network aims to double the graduation rate for undergraduate STEM students, by removing barriers and changing systems within higher education. The Network addresses barriers for all by concentrating on first-generation, low-income, and rural students, testing change ideas on campuses using a methodology called Improvement Science.

When we started out, in 2016, the persistence rate of first-generation STEM students in West Virginia—the number of first-generation students who graduated with a degree in STEM after declaring a STEM major as a freshman—was a dismal 30%, according to data reported by the Higher Education Policy Commission (2017). First2 Network research, led by West Virginia University faculty, has uncovered factors that contribute to this low percentage. For example, one important predictive academic factor is math entry point. Seventy percent of STEM students who enter college calculus-ready, graduate with a STEM degree. In our region, only 47% of non-first gen students and only 31% of first-gen and rural students start college calculus-ready. One main culprit is lack of high-quality preparatory opportunities for students at rural high schools, including fewer certified STEM teachers and fewer AP courses.

Beyond academic factors there are a myriad of affective factors that influence success. A deep understanding of the obstacles to success for first-generation, rural, low-income STEM students in higher education requires the input of students currently in the system. First2 students' lived experiences inform network goals and activities. Through our students, and backed by the literature, First2 has learned that while academic obstacles can be overcome, our students may struggle to navigate

campus resources to get the support they need once they enter college. First-generation, rural and low-income students are more likely to experience imposter syndrome and are more reluctant to seek the help they need (e.g. Anyu 2021, Nelson et al. 2019, Ramsey and Brown 2018). A recent study found that imposter syndrome, while prevalent among all students, is more strongly associated with stress among first-generation students (Holden, et al, 2021), which can lead to lower persistence.

First2 Network members work to change this narrative. Campus teams made up of students, faculty and student success staff iteratively test high-impact practices aligned with a simple theory of change. This theory incorporates four drivers of change; to increase student success, campuses must 1) enact high impact practices and policies that increase students' academic achievement, 2) improve students' feelings of belonging as a STEM major, 3) provide authentic work-related experiences and, 4) develop student leadership and agency (Figure 1). First2 Network works in true partnership with student leaders, STEM faculty and others to develop and test "change ideas" that align with one of these four change drivers. First2 Campus teams conduct disciplined inquiry to document their work, measure outcomes and share their learning with all members through a process known as Improvement Science.

What is Improvement Science?

Improvement Science is a systematic, data-driven approach to enhancing practices and outcomes across various fields, particularly in complex systems like healthcare and education. Improvement Science emphasizes iterative testing, continuous feedback, and collaborative learning. It relies on structured methodologies—such as Plan-Do-Study-Act (PDSA) cycles—to test small changes, measure their impact, and refine strategies based on evidence. The core idea is to learn "what works, for whom, and under what conditions", rather than relying on isolated or one-size-fits-all interventions (Bryk et al., 2015).

In higher education STEM programs, Improvement Science is particularly valuable for addressing challenges related to student retention, instructional quality, and equity in access and outcomes. For example, a STEM department might use Plan-Do-Study-Act cycles to redesign introductory courses, integrate active learning strategies, or as is the case in this special edition, to improve STEM students' sense of belong as members of the STEM community.

Improvement Science:

- uses a design-development ethic, learning quickly, at low cost, by systematically using evidence from practice to improve through PDSA cycles;
- incorporates "learning by doing", bringing analytic discipline to design-development efforts. For example, a professor might introduce a new classroom practice and examine student work for evidence of positive change;
- is integral to day-to-day work, this sets it apart from traditional educational research efforts;
- is problem centered and incorporates measurable outcomes or targets.

One of the most prominent examples of Improvement Science in higher education is the work done by the Carnegie Foundation for the Advancement of Teaching, which developed Networked Improvement Communities (NICs) to scale educational innovation. In these communities, institutions collaborate around shared goals, using Improvement Science principles to guide systemic reform. A well-known NIC example is the Student Success Network, which focuses on reducing achievement gaps and improving outcomes for low-income, first-generation, and underrepresented students (Bryk et al., 2015). This approach fosters adaptive learning, supports equity-focused change, and builds institutional capacity for continuous improvement.

The ability to replicate quality outcomes under diverse conditions is the ultimate goal in Improvement Science. First2 Network aims to unite the discipline of improvement science with the power of sharing across institutions to accelerate the pace of improvement. Through iterative testing and cross-institutional learning, we can adapt innovations to local contexts while contributing to broader knowledge about what supports student success (Reinholz & Andrews, 2020).

How Does it Work?

At the start of the academic year, First2 Network Campus Teams propose several change ideas to test and measure. First2 Network requires that all change ideas align with one of the four primary drivers of change (Figure 1) and that they include at least one of six outcome measures (Table 1). First2 Network support staff developed common templates for use by

teams in enacting PDSA cycles and developed common survey questions for all to use when assessing non-cognitive factors such as belonging or self-efficacy. First2 Network provides coaching to all academic teams during the "plan" and "act" phases to support robust data collection and clear documentation.

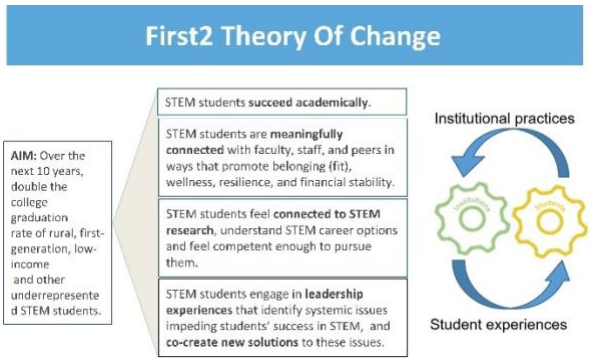

Figure 1: The First2 Network Theory of Change including primary change drivers.

Table 1: First2 Network Shared Outcome Measures
Persistence (Re-enrollment as a STEM major)
Course completion rate
Course pass rate and/or Grades
Probationary status
Grit
Belongingness
Self-efficacy

In 2024/25, campus teams enacted plans for seventy-five change ideas across the Network (Figure 2). A majority of change ideas in this year are aligned with Driver 2, "Fit and Belonging", which is the focus of this PWVAS Special Edition.

Brief Summary of Outcomes to Date

At First2 Network, campus teams use common metrics to measure success or failure of their change ideas and share what they learn with each other. First2 Network has made significant progress in changing campus systems, while providing transformational leadership experiences for students and faculty at all First2 campuses. Student leaders who are highly connected to and/or take leadership roles in the network are significantly more likely to persist in STEM majors.

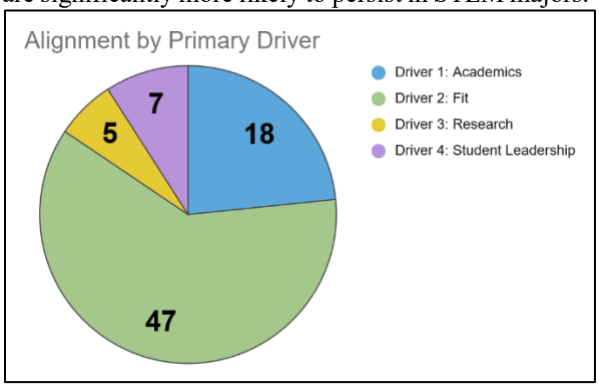

Figure 2: First2 Network change ideas underway in 2024-25 aligned by change driver.

Students who participate in **any** First2 intervention likewise show evidence of greater success and retention than their peers. First2 asks its campus teams to provide aggregated data on the overall impact of its change ideas and has compiled the results for each partner school. Across all campuses for which we have data, students who participated in First2 change ideas in 2024-2025 persisted at a greater percentage than similar groups of students who did not participate in First2 change ideas, and these findings are consistent with prior year results. At the time of this writing, First2 has received complete 2025 institutional data from five campuses:

WVU reports, out of the 2152 STEM majors that participated in at least one First2 PDSA activity, 1962 (91%) remained in a STEM degree path as of spring semester. This represents a substantially higher STEM persistence rate than the current WVU STEM persistence rate of the comparison group (56%).

Fairmont State University (FSU), a much smaller university, reported similar overall persistence data. Of the 164 STEM students impacted by PDSAs in the 24-25 academic year, 111 started college as declared STEM majors. The 111 STEM majors have substantially higher persistence rates (98% overall average to date) than the overall STEM population during those years. For comparison, the 1, 2, and 3-year retention rates are 59%, 47% and 34% respectively for all STEM students who started between 2019 and 2024.

At Shepherd University, 94% of the 114 students who participated in PDSA change ideas during 24-25 are retained as STEM majors. By contrast, on average, 46% of first year students persisted to their second year from 2019-2024.

WVU-Tech reported 100% retention for the 30 STEM majors impacted by PDSAs. For all STEM students, average persistence (2014-2024) for the cohort was 54% for freshman to sophomore and 42-39% through to Y3 or Y4, respectively.

EKU had 80 students participate in at least one change idea, and 100% retention for the 67 who were STEM majors, compared to 44-57% retention of all STEM majors from sophomore to senior year.

A Final Word

Driver 2, improving belonging, is the focus of this special edition and for good reason. Belonging uncertainty is a powerful predictor of attrition after controlling for academic preparation and demographic characteristics (e.g.: Fink et al. 2020). Engaging students in high impact practices designed to promote belonging has a positive impact on student engagement and persistence (Ribera et al. 2017).

This driver has unleashed the power and creativity of students in contributing to a better STEM culture on their campuses. As you will see represented in the authors and co-authors of the papers included in this special edition, undergraduate students have tested a significant number of change ideas designed to improve student belonging. These papers describe just some of the excellent work being done by campus teams across the network. If you are inspired to learn even more, you can access the original PDSA documents, a list of publications and more on the First2 website by becoming a member. https://first2network.org

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