

Original Research Paper

Increasing STEM Belonging and Building Social Capital for Faculty for Student Success

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Article history

Received: 17 April 2025

Revised: 24 July 2025

Accepted: 7 August 2025

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Abstract: While many institutions focus on fostering a sense of belonging among STEM students, faculty often face challenges in finding supportive professional communities. To address this gap, the NSF-funded First2 Network implemented improvement science initiatives and community-building activities designed to strengthen connections among STEM faculty across West Virginia. We surveyed participating faculty to assess changes in their perceived sense of belonging, collaborative opportunities, social capital, and connections with students. Results indicate that engagement with the First2 Network was associated with an enhanced sense of belonging within the STEM community, increased opportunities for professional collaboration to build social capital, and allowed them to feel more connected with students. The faculty also provided examples of how their participation in improvement science work has contributed to their professional growth and benefited students at their institution.

Keywords: STEM Education; Belonging; Social Capital.

Introduction

Academic institutions prioritizing faculty support is vital for the success of faculty members, ongoing research, and students within the institution. The First2 Network, an organization that connects students, faculty, and industry members, aims to improve science, technology, engineering, and math (STEM) education in West Virginia and beyond. Primarily supporting first-generation students and other underrepresented groups, this organization prioritizes initiatives to increase STEM student success. Persistence in STEM majors remains a significant challenge, particularly among first-generation students (Bettencourt, et al, 2020), those whose parents have not earned a four-year degree. This issue is especially pronounced in rural areas such as West Virginia. For these rural, first-generation students it is important to provide targeted support and interventions to help them navigate

academic challenges and succeed.

While students are the focus of First2 Network, the project also aims to connect faculty and industry members in STEM fields across the state and region. Efforts to improve student learning and to increase graduation rates in STEM majors emphasize the need for widespread use of evidence-based teaching practices in undergraduate STEM education. Achieving and sustaining such reform likely requires a significant cultural shift in how teaching is approached (Shadle et al., 2017). Faculty members often encounter multiple barriers to adopting evidence-based, student-centered practices, and comprehensive faculty support is seen as crucial for facilitating instructional change (Biswas et al., 2022)

The First2 Network supports STEM faculty to do the necessary transformative work in several ways, including holding conferences with key stakeholders and by facilitating improvement science projects on various campuses across the state whose results are

then shared with other campuses.

Improvement science is a technique that aims to enhance education by enacting rapid cycles of changes and review (Lewis, 2015). For example, faculty, administrators, and students might collaborate to establish a centrally located STEM-focused tutoring center for introductory courses, and then assess whether this initiative positively impacts students. These short-term projects are known as Plan-Do-Study-Act (PDSA) cycles and are planned and implemented. Outcomes are studied, typically through persistence and engagement data, and the techniques being tested are kept, altered, or discarded based on the results.

The First2 Network also promoted other initiatives that sought to improve belonging and connect people to improve networking and productivity. The First2 Network held annual or bi-annual conferences where faculty would gather and exchange ideas. The network also promoted working groups, first across institutions and then within institutions. These working groups engaged in Improvement Science work and members implemented Plan-Do-Study-Act activities on their campuses and measured the effects on their students. The network also facilitated the writing of joint publications about specific network activities.

This paper will examine how faculty members' sense of belonging, social capital, and connection to students in STEM departments change as a result of participating in the First2 Network's improvement science activities and other initiatives. We hypothesize that faculty who engage with these activities of the First2 Network will experience increased sense of belonging, greater social capital, and stronger connections to their students.

The authors recognize that such a collaborative network and activities would benefit faculty across all disciplines. However, this study specifically focuses on STEM faculty, as they comprise the participant group within the First2 Network. Although this study centers on STEM faculty within the First2 Network, the principles and collaborative approaches outlined here have broad relevance and could similarly enhance faculty support, professional development, and student outcomes in non-STEM disciplines.

Sense of Belonging

A sense of belonging is a fundamental human need

(Maslow, 1954). In academia, there are extensive research findings regarding the positive impacts of sense of belonging on students' persistence, career interests, and academic performance (Shortlidge, et al, 2024; Xu & Lastrapes, 2022; Li & Singh, 2023). However, the primary focus on students in sense of belonging research overlooks the importance of faculty experience and outcomes in STEM fields. Paxton (2021) found that a sense of community and belonging increased job satisfaction and perception of success for faculty. Additionally, retaining faculty in STEM high school classes increased with a sense of belonging for faculty (Balgopal, et al, 2022). This is vitally important for K-12 where rates of teacher retention are a major contributor to teacher shortages, especially in STEM fields (Brown & Wynn, 2007). In higher education, there is low recruitment and retention of underrepresented minority scientists in STEM fields (Campos, et al, 2021). If longevity of faculty in STEM fields is to be increased, creating a sense of belonging for them is important.

Social Capital

Another aspect related to college faculty career success and longevity is social capital. Social capital theory encompasses ideas of how social networks and relationships inform shared values, trust, reciprocity, and cooperation (Motkuri, 2018). Generally, obtaining higher social capital allows individuals to work with others within and outside their institutions, increasing the output of professional relationships. In academia, social capital increases knowledge sharing within institutions (García-Sánchez, et al, 2019), and increases productivity (Gonzalez-Brambila, 2014). Social capital broadens social networks, increasing a researcher's academic visibility (Filipovic, et al, 2023). Building social capital as a faculty member is essential for success. By connecting faculty and building their collaboration network and academic output, the institution where they serve is strengthened and output increases.

Social capital connections relate to both inside and outside one's institution. Bonding social capital refers to the connections within an institution between people in a similar field, while bridging social capital refers to the connections between individuals in groups that are dissimilar, like faculty at other institutions. The third aspect of social capital is linking, or ties to work colleagues in different hierarchical positions (Claridge, 2024); for faculty this could mean administrators or

possibly industry or government employees. All aspects determine the strength of an organization or network, like First2 Network, and its ability to connect faculty to diverse groups of people.

Student Connection and Support

Increasing STEM belonging and social capital impacts faculty and students. Faculty longevity positively impacts students through many facets. Most notably, faculty connections strengthen persistence and retention in students (Estep, et al, 2023; Crowe, 2021; Lau, 2003; Shelton, 2003). According to Lau (2003), faculty maintaining positive relationships and environments enhances student motivation. Another positive aspect of faculty support for students is higher self-efficacy, GPA, and academic confidence (Vogt, 2008), as well as increasing sense of belonging (Estep, et al, 2023). This indicates that support impacts how students view their competence and ties with others in their organization, leading to better academic performance and retention.

In terms of social support, Glass et al. (2017) found faculty provide immense support for first-generation international student's involvement in campus life. These students, while not the focus of organizations like the First2 Network, are an underrepresented group in STEM programs, and can encounter similar barriers as other underrepresented groups (Preuß, et al, 2025). With higher longevity, faculty are more likely to guide international students through an unfamiliar social environment, increasing feelings of belonging in students. The quality of student-faculty interactions influences the outcome of these interactions. Dika (2012) identified higher achievement for students when faculty/student interactions are high quality, rather than high quantity. Essentially, faculty who are securely established in an institution and generate high quality interactions with students tend to increase a student's sense of belonging and academic success.

Connecting to students has a positive impact on faculty's peer networks. Middleton et al (2015) found that faculty that were learning focused had deeper and more extensive social networks. This finding suggests that further interaction with students may increase a faculty member's connections with other faculty, thus building more social capital. This correlation highlights the dual benefits of student-faculty interactions, with academic success,

confidence, and social support increased for students, and better social networks for faculty. In this model, sense of belonging, social capital, and connection to students are interconnected; an increase in student connection increases sense of belonging and social capital.

Methods

Study Design

This exploratory, mixed-methods study was conducted to assess the development of faculty sense of belonging, social capital, and student connections within the First2 Network. The study was reviewed and approved by West Virginia University Institutional Review Board (protocol number 2501095581).

Participants

Participants included faculty associated with the First2 Network from institutions across West Virginia. Recruitment took place through emails to First2 faculty members and invitations distributed through the network newsletters. Participation was voluntary, and no incentives were offered. The final sample consisted of 73 individuals, including 51 faculty members and 22 others (students, industry partners, etc.), who met at least one of the following inclusion criteria: (1) completion of the annual Social Network Analysis Survey in the past three years, (2) participation in the network's Plan-Do-Study-Act (PDSA) review process, or (3) co-authorship of publications or presentations related to the First2 Network during the project period.

Data Collection Instruments and Methods

Data collection was accomplished through survey instruments, targeted questionnaires, and bibliometric analysis of publication network to assess faculty perceptions of belonging, social capital, student connections and collaborative connections. This section describes the instruments and methods used.

First2 Faculty Belonging and Social Capital Survey: This survey was divided into three sections. The first section included author-developed retrospective items assessing social capital, based on the framework by Claridge (2017). Faculty were asked to rate, using Likert scales, the extent of their

professional collaborations both prior to and following their involvement in the First2 Network. Social capital was measured across three domains: bonding (collaboration with peers within the same organization), bridging (collaboration with peers at other organizations), and linking (connections that span institutional hierarchies or authority gradients). They rated their connections to others using a scale from 1 (no connection), 2 (weak connection), 3 (moderate connection), and 4 (strong connection). Pre- and post-network engagement scores provided a measure of perceived changes in social capital.

The second section consisted of adapted items from two validated instruments: the Brief Sense of Community Scale (Peterson, Speer, & McMillan, 2008) and the Sense of Belonging Instrument (Hagerty & Patusky, 1995). These Likert-type questions assessed participants' perceptions of belonging specifically within the First2 Network context. They were asked to rate each statement on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree).

The third section contained author-developed Likert-scale questions exploring faculty perceptions of their ability to connect with students after participating in the First2 Network. These items aimed to determine whether faculty perceived that their student engagement had improved as a result of their network involvement. They were asked to rate each statement on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree).

It should be noted that no reliability analysis was conducted on the modified or newly developed items in the current survey.

Plan-Do-Study-Act (PDSA) Questionnaire: A brief questionnaire was administered to faculty engaged in improvement science work through PDSA cycles on their campuses. Respondents reported which PDSA activities they participated in and described the perceived impact on both students and themselves.

Publication Network Analysis: Connectivity and collaboration were further assessed through a bibliometric analysis of academic publications related to the First2 Network. Thirty relevant publications were identified, collectively authored by 46 individuals: 16 First2 Network faculty, six non-network faculty, 13 First2 Network students, five non-network students, and six professionals from outside academia. Co-authorship patterns were mapped to show collaborative clusters and inter-institutional connections, thereby providing a way to

visualize the professional network fostered by First2 Network activities.

Data Analysis

Survey responses were analyzed using descriptive and inferential statistics to assess changes in perceived belonging, social capital and student connections. Qualitative responses underwent thematic coding to identify salient themes. Authorship data were visualized using NodeXL to observe patterns in authorship collaborations across the network.

Results

This section summarizes findings from the First2 Faculty Belonging and Social Capital Survey and related instruments assessing faculty social capital, belonging, and connections with students in the First2 Network. The analyses describe associations and reported changes in faculty bonding, bridging, and linking social capital, as well as faculty belonging and student connections. While the data reveal statistically significant associations and changes, causality cannot be inferred; instead, these results highlight trends that may inform future research and practice.

First2 Faculty Belonging, Social Capital Survey and Student Connections

Twenty-three faculty associated with the First2 Network completed the First2 Faculty Belonging and Social Capital Survey. The first section examined social capital. These respondents showed an increase in all three areas of social capital: bonding, bridging and linking (Claridge, 2024).

To investigate bonding, we used the faculty member's shared social characteristics of the same institution and in STEM and determined changes in these connections. Faculty increased in connections to colleagues at their institution in other STEM disciplines and increased in connections to other faculty at their institution in their discipline.

For bridging, we considered being at another institute of higher education and in STEM as the different social characteristics. Faculty increased in their bridging with others outside their institution, both in their STEM discipline and outside their STEM discipline. For linking, we used connections to others in different hierarchical positions, both inside their academic institution and outside, in industry. Faculty increased in linking with others in different positions.

To assess the significance of these increases, six paired-sample t-tests were conducted. To account for the increased risk of Type I error associated with multiple comparisons, a Bonferroni adjustment was applied, resulting in an adjusted significance threshold of 0.0083 (0.05/6). After this adjustment, significant increases were observed in connections with colleagues at their institution in other STEM disciplines, colleagues outside their institution in their own and other STEM disciplines, and industry professionals (all $p < 0.0083$). Increases in connections to colleagues within their own institution in their discipline and to institutional administrators did not reach the adjusted significance level. In addition, Cohen's *d* effect size was calculated for each item. Three questions demonstrated a large effect size ($d > 0.80$), two showed a medium effect ($d > 0.50$), and only one was considered a small effect ($d < 0.50$). Survey items, their associated social capital categories, pre- and post-means, mean differences, paired t-test p-values, and effect sizes are presented in Table 1.

Table 1. Social Capital Survey Questions

Survey Item	Area	Mean		Inc	p-value	Effect size
		Pre	Post			
I feel connections to...						
Colleagues at my institution in my discipline	BO	3.4	3.75	0.35	0.0692	0.4418
Colleagues at my institution in other STEM disciplines	BO	2.8	3.4	0.6	0.0020*	0.8950
Colleagues outside my institution in my discipline	BR	2	2.65	0.65	0.0009*	0.8165
Colleagues outside my institution in other STEM disciplines	BR	1.95	2.75	0.8	0.0007*	0.9177
Administrators at my institution	LI	2.95	3.25	0.3	0.0298	0.5388
Industry Professionals	LI	2.1	2.45	0.35	0.0047*	0.7338

*Significant at the $p < 0.05/6 = 0.0083$ level.
 BO = Bonding, BR = Bridging, LI = Linking

The second part of the survey related to belonging. There were eight questions pertaining to belonging as it relates to the faculty's involvement with the First2 Network. Faculty were asked to rank each statement. Eighty percent (80%) of the

respondents felt connection to the First2 Network, seventy-five percent (75%) felt that people in the First2 Network were good at influencing each other, and seventy percent (70%) felt they had a bond with others in the network. However, only sixty percent felt a sense of belonging (60%) to the First2 Network and one-fourth (25%) of the disagreed or strongly disagreed with feeling a sense of belonging. Table 2 summarizes the responses to these questions.

Table 2. Belonging in First2 Network

Question (N=20)	Mean	1 (SD)	2 (D)	3 (N)	4 (A)	5 (SA)
I feel connected to the First 2 Network.	4.02	2 10%	0 0%	2 10%	7 35%	9 45%
I have a good bond with others in the First2 Network.	3.85	2 10%	1 5%	3 15%	6 30%	8 40%
The First2 Network helps me fulfill my needs (Note: N=19).	3.21	2 11%	3 16%	6 32%	5 26%	3 16%
I have a say about what goes on in the First2 Network.	3.40	2 10%	3 15%	4 20%	7 35%	4 20%
People in the First2 Network are good at influencing each other.	3.90	1 5%	1 5%	3 15%	9 45%	6 30%
I feel a sense of belonging to the First2 Network.	3.65	1 5%	4 20%	3 15%	5 25%	7 35%
I feel that I am a member of the First2 Network.	4.00	1 5%	4 20%	0 0%	4 20%	11 55%
I see myself as part of the First2 Network	4.00	1 5%	4 20%	0 0%	4 20%	11 55%

The final part of the survey pertained to student connections. Participants were asked to rate statements regarding their feelings of connections with STEM students because of membership in the First2 Network. The highest rated statement was "I understand the student perspective better" with seventy percent (70%) saying they agreed or strongly agreed with this statement. The First2 Network made a concerted effort in all activities and events to make sure students' voices were heard. The other statement that was rated highly was "I feel more equipped to support students." Fifty percent (50%) of faculty agreed or strongly agreed with this statement. Table 3 shows the responses to these survey questions.

PDSA Questionnaire

Six faculty members who were part of First2 Network and completed a Plan-Do-Study-Act project on their campus in the last three years responded to the questionnaire. The responses were coded and analyzed

for recurring themes, which are summarized below.

Table 3. Faculty Perceptions of Connections with Students

Question (N=20)	Mean	1 (SD)	2 (D)	3 (N)	4 (A)	5 (SA)
I feel more connected to my students.	3.45	1 5%	2 10%	9 45%	3 15%	5 25%
I feel more equipped to support students (N=19).	3.68	1 5%	1 5%	7 35%	4 20%	6 30%
I understand the student perspective better.	4.00	1 5%	1 5%	4 20%	5 25%	9 45%
I feel more confident in my ability to relate to students.	3.50	1 5%	2 10%	8 40%	4 20%	5 25%
I believe my students find me more approachable	3.40	1 5%	2 10%	9 45%	4 20%	4 20%

Q1: Have you been involved with one or more Plan-Do-Study-Act (PDSA) activities as part of your involvement with First2? If yes, will you list them?

The six respondents had been involved with 18 different PDSAs on their respective campuses. The list included: Embedded students, Embedded help sessions, Summer Bridge Program, Sci-Tech Social, Campus STEM Clubs, Summer Research Experiences, Faculty Mentor Training, STEM Student Listserv, Peer Tutoring, Professor Panel, STEM Student Panels, Appalachian Culture Projects, Reducing Math Anxiety, and Enhancing Student Voice. These PDSAs generally serve to connect students to each other, faculty, and resources on campus.

Q2: List the ways that your PDSA work has helped students with whom you interact at your institution. Please be specific.

The faculty responded at length on PDSA activities that affected students. In all cases, there were positive outcomes resulting from the activities, such as increased student engagement, improved academic performance, higher retention rates, and scholarship awards for some participants. The comments fell into five main categories.

The first category was **Academic Support and Skill Development** was reported by four faculty members. One faculty discussed how the embedded help sessions provided consistent academic support throughout the semester to reinforce concepts in entry level courses. Another faculty member discussed how weekly reports given by embedded

students helped students reflect on their learning strategies, metacognition, motivation and time management. The reports also gave faculty anonymous feedback to allow them to adjust teaching based on student perceptions. Another faculty project facilitated students learning about growth mindset, math anxiety, mindfulness, self-compassion, and reframing failures which helped students overcome anxiety in certain courses. The fourth faculty member discussed efforts to reduce math anxiety through several methods, like mindfulness and self-compassion.

The second category, **Early College Experience and Transition**, was mentioned by three faculty members. One faculty member mentioned that early summer and academic year research experiences increased student’s sense of STEM belonging, STEM identity and STEM efficacy. One faculty member mentioned a summer one-week bridge program which introduced students to college life, campus resources, and study strategies in a more relaxed setting before they started their first semester of college. Another mentioned campus acclimation activities that included class schedule walkthroughs and resource scavenger hunts, aimed to increase students’ comfortability on campus.

The third category was **Engagement and Relationship Building**, which was mentioned by three faculty. Faculty devised multiple ways to engage students outside the classroom, like holding a professor panel to increase student comfort in engaging with professors and fostered a sense of belonging and confidence to seek academic support. Other events such as the Sci-Tech social encouraged connection between students and faculty through interactive activities. The embedded student feedback project improved the instructor/student understanding through anonymous feedback that the faculty could act upon.

The fourth category was **Career and Research Opportunities**, which was mentioned by two faculty members. One faculty member discussed a project where students were provided weekly emails containing STEM-focused opportunities both on and off campus. This project was seen to encourage STEM engagement and STEM career development. The faculty mentor training was also mentioned in this category, as it helped students by enhancing faculty members’ ability to mentor undergraduate students, especially first-generation and underrepresented students, in undergraduate

research experiences.

The fifth category was ***Personal Growth and Identity***. Three faculty members pointed out that many of the activities were used to help students gain a sense of belonging in their STEM fields, to increase their STEM identity and efficacy by doing STEM research activities, and to develop a growth mindset.

Another two comments by faculty members mentioned that students had access to financial resources through the First2 Network.

Q3: List ways in which the PDSA work has helped you grow professionally.

Faculty responded that the PDSA work helped them grow professionally in many ways. Based on the responses, they listed seven main ways that the work helped. Faculty responded that they grew in the area of ***Research and Project Development*** by doing the PDSA work of the First2 Network. Four faculty members mentioned they developed and implemented projects, conducted research studies, expanded projects across multiple courses and semesters, and that they had funding to assist them in these efforts. Another way the faculty said they grew was through ***Networking and Collaboration***. Four faculty members mentioned this area saying: they connected with like-minded researchers studying similar topics; interacted with new people; found collaborators on their campuses in different departments; and joined national groups related to topics they worked with on their PDSA.

Another important area of growth was ***Academic Writing and Publishing***. One faculty member mentioned that academic writing was new to them. Another two faculty members mentioned they were able to write about the work they did in a PDSA and published research about it in academic journals. One person said they were able to develop multiple research papers based on their topic. Related to the writing and publishing faculty mentioned ***Presentation and Conference Participation***. One person said that they presented their PDSA work at regional and national conferences, and another gave oral and poster presentations about their research.

Four faculty members also mentioned growth in ***Skills Enhancement***. One mentioned improved program evaluation and research design skills, and another enhanced data analysis and interpretation abilities. One person said they refined student engagement strategies, and another said they learned

to apply research concepts in academic settings.

Four faculty members mentioned there were other areas of ***Career Development***, such as mentoring graduate students, developing faculty mentoring programs, exploring literature in different fields, and transitioning projects into sustainable, campus-wide initiatives. Three faculty responded that all these PDSA related activities resulted in ***Recognition and Impact***. The faculty celebrated shared successes, contributed to the field through publications and presentations and influenced teaching practices and student learning outcomes.

Publication Network

For academic faculty, engaging in scholarly publications is not only critical for their career advancement, but also serve as an avenue for building social capital and fostering a sense of belonging within academic communities. Within the First2 Network, these opportunities were created through intentional collaboration aligned with network aims. As mentioned earlier there are some 30 publications written about the First2 Network by 46 co-authors. Figure 1 illustrates the Publication Network: each node represents an individual, with lines denoting co-authorship, including both intra- and inter-institutional collaborations. Loops on certain nodes indicate single author works. The visualization reveals several densely interconnected clusters, indicating robust collaboration among network members and showcasing how these research endeavors reinforce social capital.

The publication network demonstrates the involvement of both students and faculty members as co-authors and the presence of connections with individuals outside of one's own institution. This activity provided opportunities for both mentorship and broadening professional circles. The figure's design helps to show these affiliations: solid nodes for First2 members, open nodes for non-members, with squares symbolizing faculty, circles for students, and triangles for non-academic collaborators. With participation from five West Virginia higher education institutions (Fairmont State University, Marshall University, West Virginia School of Osteopathic Medicine, West Virginia State University, and West Virginia University), along with K-12 educators and representatives from the National Radio Astronomy Observatory, the collaborative environment of the First2 Network directly addresses the research

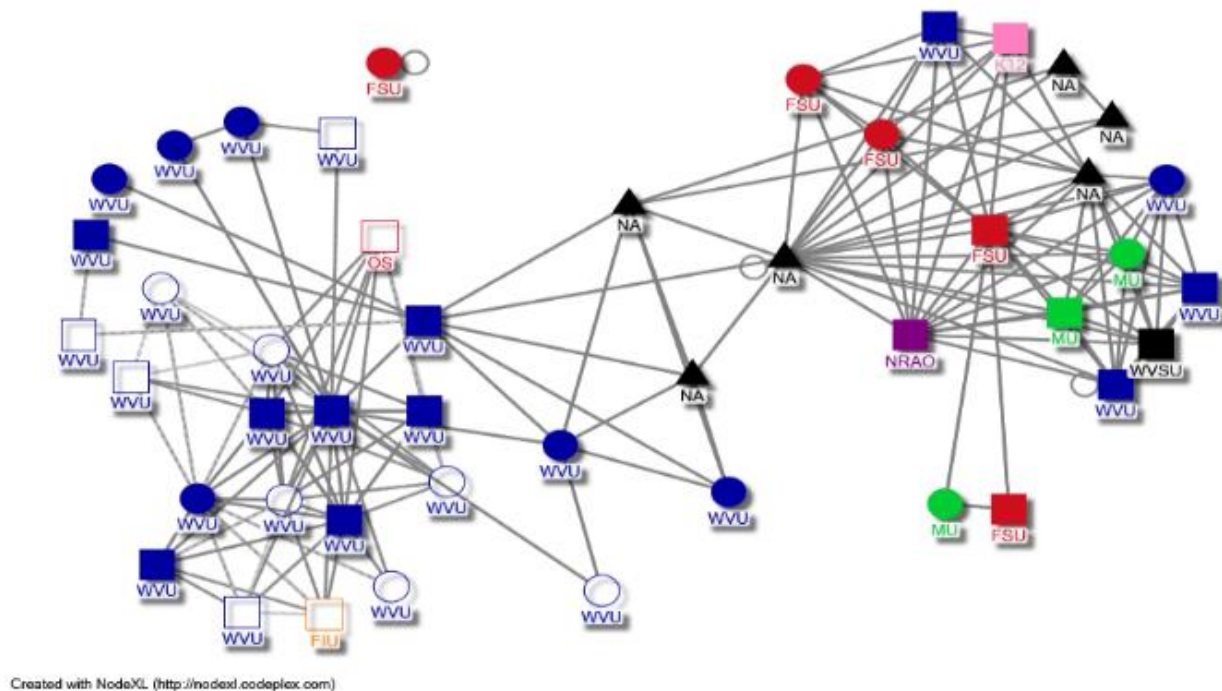


Figure 1. Publication Network. The nodes are the individuals labeled with their organization. All First2 members have solid nodes, non-First2 individuals have open nodes, squares are faculty members, circles are students, and triangles are non-academic people. Colors indicate organizations. Connections between nodes are co-authorships on publications.

hypothesis. Specifically, by engaging with First2 Network's goals, faculty have enhanced their sense of belonging in STEM, expanded their social capital through meaningful co-authorship, and deepened their connections to students.

Discussion

It is vital for faculty in academic institutions to find a professional community in which they can grow and thrive. Often their advancement and careers depend on their ability to make connections with other like-minded professionals (Paxton, 2021). Through this study, we investigated how faculty members who participate in the First2 Network have made connections with others and grown professionally. The information collected from participants has shown that First2 Network members have increased social capital in all areas, but especially in the area of bridging with others in STEM disciplines outside of their own home institution. While social capital within institutions

and the same discipline did not significantly increase, this is likely because faculty were connected to other faculty in their discipline prior to the First2 Network. These results are similar to past studies that found that increased social capital is related to increased knowledge sharing, academic visibility, and broader social networks (García-Sánchez, et al, 2019; Filipovic, et al, 2023).

The survey also revealed that First2 Network members perceived a sense of belonging. Many (80%) of the survey respondents felt connected to others in the network, and seventy percent (70%) said they had a bond with others in the network. It appeared most respondents felt they had connections within the network, only 15% disagreed or strongly disagreed. Less respondents felt a sense of belonging in the First2 Network, one fourth (25%) disagreed or strongly disagreed. This difference indicates that while participants felt they were connected to the network, some did not feel like they belonged to it. This contradiction may stem from the idea that connection is to individuals in the organization, while belongingness suggests feelings of acceptance

and being a part of an organization (Hurem, et al, 2021). Sense of belonging is important to develop in academic careers, as it increases job satisfaction, perceptions of success, and faculty retention (Paxton, 2021; Balgopal, et al, 2022). Future goals of the First2 Network and similar organizations should focus on increasing sense of belonging to mirror sense of connection.

When asked about connection to students, respondents felt they understood the student perspective better after participating in the First2 Network (70%). They also reported they felt more connected to students and more equipped to support students. Being able to connect and understand students was vital for increasing the students' feeling of belonging (Glass, et al, 2017).

The First2 Network PDSA work has clearly provided excellent opportunities for faculty professional growth across many academic and research areas. These activities correlated with an increase in sense of community and belonging, increasing satisfaction and perception of success (Paxton, 2021). The PDSA work is also correlated with building social capital for faculty, likely by connecting them to others both inside and outside their institution. Faculty made connections with others in their STEM fields and outside their STEM fields, thus increasing in linking and bonding according to Claridge (2024). With increased social capital through PDSA work, faculty theoretically increased knowledge sharing (García-Sánchez, et al, 2019) and increased productivity (Gonzalez-Brambila, 2014). Faculty also mentioned that through the First2 Network they published papers, attended conferences, and gave presentations, thus increasing a researcher's academic visibility (Filipovic, et al, 2023).

The publication collaboration shows strong working connections between faculty within and outside of their institutions, as well as outside of their academic positions (i.e. faculty to students). This finding can model the development of both bridging and bonding social capital for participants of the First2 Network. In the area of bonding for the faculty who are in similar STEM disciplines or who were interested in similar projects to help students, publications strengthened ties among these researchers with like interests (& Li, 2024). These joint publications have helped faculty with bridging by connecting them across different research programs, departments, and institutions (Fagan, et al,

2018). The publication network serves as a clear measure of collaboration, linking faculty who might not otherwise interact. These working relationships can also facilitate the dissemination of information across diverse groups (Chen & Li, 2024). Collaboration on publications can also foster a sense of belonging by integrating faculty into a community. By publishing, faculty are actively participating in their academic community, which enhances their sense of belonging (Chen & Li, 2024) and increases their visibility within their field, leading to recognition and possibly opening up new opportunities (Lubka, 2025).

Limitations and Future Directions

One major limitation of this study was the lack of a comparison group. It is difficult to definitively argue that organizations like the First2 Network, and their activities and opportunities, are solely responsible for the increase in sense of belonging, social capital, and student connections. As this study was exploratory in nature, it focused on the success of the improvement science activities. Future studies should include a comparison group to validate these findings.

Another limitation of this study was the small sample size. This is due to the small number of faculty who fit the criteria (faculty who worked with the First2 Network) and a small survey response. In the future, studies should survey a wider sample of faculty who are involved with improvement science, both within and outside of the First2 Network. Additionally, studies should expand beyond West Virginia, and survey faculty in other states. These two modifications will increase the generalizability of the findings.

Additionally, as faculty chose to engage in the First2 Network, these participants may be more likely to collaborate with faculty and students, leading to a self-selection bias. Also, the lack of psychometric validation of some survey items poses a limitation. Future studies should address these limitations with a wider demographic of participants, and include ensure that all survey questions are validated.

The difference between faculty connections to other faculty and students should be compared between large and small academic institutions. The size of an institution may impact a faculty member's ability to connect with others, as well as the strength

and depth of these connections.

Conclusion

Drawing on the findings of this study, we recommend incorporating First2 Network initiative, specifically the improvement science and PDSA activities, into academic institutions. Faculty who participated in these initiatives reported greater social capital, a stronger sense of belonging, and deeper connections with students. Our results suggest that engagement with improvement science is associated with enhanced community and academic success among faculty.

Acknowledgements

This work was supported in part by the National Science Foundation under collaborative award Nos. HRD-1834586, 1834595, 1834601, 1834575, 1834569. Any Opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect those of the National Science Foundation. We thank Leah McJilton for the publication network graphic.

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