Networked Improvement Communities as Tools for Teacher Empowerment

Joshua Childs
Texas Advanced Computing Center
The U of Texas at Austin
Austin, TX
joshuachilds@austin.utexas.edu

Rebecca Zarch
Director
SageFox Consulting Group
Amherst, MA
rzarch@sagefoxgroup.com

Ryan Tobrey
Department of Curriculum and Instruction
The U of Texas at Austin
Austin, TX
Ryan.torbey@utexas.edu

Carol Fletcher
Texas Advanced Computing Center
The U of Texas at Austin
Austin, TX
cfletcher@tacc.utexas.edu

***Abstract*—Research literature has documented how computer science (CS) teachers are often isolated in their schools and are less likely to collaborate as compared to other subject area teachers. This parallels an emerging body of literature around how teachers leverage professional development opportunities to engage in their practice. However, limited research has empirically studied how professional development opportunities lead to increases in teacher empowerment and spur broadening participation in CS efforts. In this study, we report on a networked improvement community (NIC) focused on connecting CS teachers to their peers, national experts, professional development providers, and researchers to impact teaching practices and guide implementation of policies that lead to increased female participation in CS courses. We report on the role of the NIC to support teachers as school and community change agents. Drawing from focus groups with participating teachers (n=20), we report on a two-year process of learning that involved identifying root causes for female underrepresentation and conducting teacher-led interventions within their classrooms and schools. We detail how a NIC offers a novel approach to facilitate collaboration and empower teachers to implement changes that can impact girls in computer science. Initial data indicate that the collaborative nature of the NIC and its teacher-directed approach to change led to a newfound sense of ownership and empowerment in NIC teachers for addressing the challenge of increasing female participation in CS.**

Keywords—Computer science education, networked improvement community, research-practitioner partnership, broadening participation in computing.

I. Introduction

In Texas, there has been a lack of representation of girls and minoritized student groups in high school computer science classrooms for many years [1], [2]. Prior research has documented how computer science teachers often feel isolated due to the small number of peers who teach computer science courses in schools [3]–[5]. Fletcher et al. (2020) previously recognized that networked improvement ccommunities (NICs) are useful for solving problems of equity within computer science education [6]. The purpose of this experience report is to highlight how the NIC that was part of the NSF-funded Accelerating Women's Success and Mastery in Computer Science (AWSM in CS) grant helped to spur teacher empowerment through collective engagement, shared strategies, and improvement tools.

AWSM in CS (pronounced "Awesome in CS") is a project focused on improving the enrollment, access, and retention of young women in secondary computer science classrooms in Texas. Through a NIC consisting of 20 secondary computer science teachers, district central office staff, evaluator consultants, and university-based researchers, a process of practitioner-driven professional development has been deployed to improve teachers' capacity to impact female participation in CS.

II. NICs as a tool of Improvement Science

The NIC is a problem-solving mechanism grounded in improvement science. The AWSM in CS NIC deployed root cause analysis conducted by teachers to unearth their perceptions of the core drivers of underrepresentation of female students in CS. NIC leaders shared research-based practices for addressing some of these root causes. Then, rather than requiring all teachers to implement specific interventions pre-defined by researchers, teachers engaged in the Plan, Do, Study, Act (PDSA) process to plan a specific intervention and study its effectiveness in their own context [7]. The PDSA approach contrasts with the traditional experimental research design and educator management approach that is focused on training teachers in a strategy, curriculum, or pedagogical method that they are then all expected to replicate. In the NIC, teacher expertise is explicitly valued. While teachers were provided with research-based strategies that promote inclusive CS programs, each teacher chose and developed the intervention that they determined would best address the root causes of underrepresentation present in their own schools or districts. Teachers then developed a PDSA in which they planned an intervention, implemented it, collected data about its impact, and then reflected with their NIC colleagues on how they would iterate on the intervention to improve outcomes the next time.

III. Focus Group Data

Twenty educators from the AWSM in CS NIC participated in focus group interviews. Participants are middle or high school teachers in school districts located primarily in Central Texas. The majority of the teachers identified that they were the only

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CS teacher in their school, with a few exceptions. Virtual focus groups were held with all twenty teachers during the second AWSM in CS summer training in June 2020. The 45-minute focus groups of 4-5 teachers were held over three days in coordination between the lead evaluator, Rebecca Zarch, and the lead researcher, Joshua Childs. An intensive protocol guided the discussion to uncover themes related to the five dimensions of RPP effectiveness. There dimensions guided an investigation of specifically how well the partnership was working; how, if at all, the partnership's research impacted the districts and students, particularly related to female students; and if the changes and knowledge created by the RPP resulted in lasting changes to organizational structures and/or the professional roles of members of partner institutions. The focus group data was transcribed and analyzed by the evaluator for alignment with each of the five dimensions of RPP effectiveness. They were then analyzed by the researcher to further probe for evidence of teacher empowerment.

IV. Results

Findings highlighted that teachers were beginning to see the impact of their collaborative efforts resulting from their involvement in AWSM in CS. There was also a recognition that while teachers were seeing impact, actually seeing sustainable and scalable change in annual enrollment of female students would be a longer process. Many teachers shared that NIC activities were forcing them to examine their own pedagogical practices, implicit biases, and stereotypes. This led many of them to think about how to change their course content to be more culturally relevant and impactful for students. Teachers also reported that they had learned how to bring in more diverse examples for students to engage with, including scientists of color, people with disabilities, and those with critical viewpoints of computer science. Finally, teachers discussed shifting classroom projects to focus on diversity of representation and developing clubs that targeted minoritized student populations. Many of these new practices were perceived by teachers to be within the traditionally defined responsibilities of a teacher.

The AWSM in CS NIC also allowed teachers to begin thinking and engaging in systemic changes within their schools that extended beyond their traditional perceptions of their own influence as a classroom teacher. Teachers reported working within their schools to build relationships with counselors to educate them about the CS opportunities for students with an emphasis on inclusion of girls. They were also revising course descriptions to make them more inviting, demystifying CS by opening classroom spaces to more students, and using peer recruitment to reach the girls in the school. At the district level, teachers were addressing policy issues by improving alignment between middle and high schools courses and content. NIC participants also were working towards more formalized CS pathways that were easier to understand and navigate. These examples of empowerment that teachers expressed during focus groups can be traced back to the functions of a NIC. Each of these strategies represented a new approach to change that recognized teachers' capacity to have influence beyond the four walls of their classroom, something that most teachers had not previously considered or attempted.

A. Building trust and relationships

NICs are predicated on a strong set of relationships among members and the organizing team. The AWSM in CS NIC developed a strong community among members through a variety of activities that engaged each participant. One important component, however, was that several members had prior experiences working with the PI and lead facilitator of the NIC. This allowed a level of comfort and trust that was already pre-embedded within the NIC. Focus group discussions also highlighted that there was a shared commitment to the problem of practice (the representation of girls in computer science education) and that teachers and other NIC members working together towards a common goal assisted in strengthening relationships. NIC teachers described feeling respected for their time, professional experiences, and expertise as it related to computer science education. There were also organizational structures that helped to promote collaboration, including a mutual commitment to support and accountability through the PDSA approach. Specifically, the organizers allowed space for the members of the NIC to collaborate and mutually problem solve amongst themselves. Reporting that they felt isolated in their individual schools and districts as computer science teachers, the NIC provided participants a space for them to build community with teachers with whom they are not direct colleagues. The leadership team took appropriate measures to ensure that the teachers were connected with each other regularly, and created a culture where teachers felt supported as well as comfortable being vulnerable and sharing their expertise with each other. Regular meetings and communication has been essential for this process. As one teacher said, "I think the networking part has been a huge thing for me, even though I've only lightly been able to exploit it, I intend to do more of that future."

B. Building the capacity of participations to engage in partnership work

Building capacity for the participants to engage with the NIC requires clear roles and responsibilities. At the start of the NIC, the exact overarching goals were left overly vague and caused teachers to be confused about what exactly their roles would be in improving female participation in computer science. Some questioned whether collaboration and PDSA interventions would achieve the rate of change necessary to make a difference. Over time, the specific goals of the NIC became clearer to participants, and the teachers felt more entrenched with the work. Teachers grew into appreciating what was taking shape and likened the NIC to a "think tank" around engagement of girls in computer science.

C. Using research to inform action

AWSM in CS was designed to use research to inform the continuous improvement efforts around engaging female students in computer science. To ensure the teachers were grounded in a shared sense of the problem, AWSM in CS leadership provided members with an overview of the current research on girls and women in computing in education and in the workforce. This information was used by members to engage in a root cause analysis regarding the underrepresentation of girls in computing, develop their PDSAs, and to assist each other to become well-informed advocates in their schools and

districts. Specifically, the research on implicit bias has affected the way teachers engage with their students, including the words they use or examples they have brought into their own classrooms. Finally, the PDSA provided a structure for the teachers to engage in and share original research.

D. Support partners in achieving their goals

The tools and resources provided through AWSM in CS have supported the community of teachers in making localized change. Research was used to inspire more inviting and inclusive teaching practices, while also providing frameworks for teachers to engage in computer science advocacy on their school campuses. The AWSM in CS structure provided an environment for meaningful sharing across contextual boundaries. This includes the combination of in-person and virtual meetings (pre-COVID), and an interactive learning platform that allowed for teachers to remain connected as their schools and districts closed due to the pandemic. Each month during the school year, the NIC met virtually and 3-4 teachers from the group shared their PDSAs and their results, getting feedback from researchers and colleagues to improve upon their practice. The PDSAs and monthly community calls were important mechanisms for accountability to the group and guided the exchange of knowledge and experiences among NIC members. Teachers who were slated to present to the group each month had to prioritize completing their personal PDSA and reflecting on successes, challenges, and next steps. Teachers expressed that the long-term engagement and provision of research examples can be used to develop action steps and advocate within their schools and districts. AWSM in CS NIC participants also reported feeling a strong sense of ownership over the work that was taking place within the NIC, and seeing it as being transferable to their own respective classrooms.

E. Produce knowledge that can inform educational improvement efforts broadly

The structures in place in the NIC (trust and strong relationships, a shared problem of practice, and common tools) have facilitated the development of strategies that allow for producing knowledge that benefits the members of the NIC. The influence of the NIC can be seen on teacher confidence and understanding of the issues as well as insights into specific alignment and advocacy efforts. For example, teachers are demonstrating confidence to make a local change; peer-modeling ways to engage with administrators to make systemic changes; sharing information that is relevant and timely; gaining insight into how other schools operate, including the schools' cultures of CS teacher support and district level CS policies; and creating vertical alignment between middle and high school CS, including what math and technology skills students have/will need.

V. DISCUSSION

Traditional teacher professional development often treats educators as technicians rather than experts who bring a deep well of experience and understanding to a professional development experience. In short, teachers are told what to do by outside "experts" and expected to replicate the "solution" with fidelity. Little attention is paid to leveraging a teacher's expertise to analyze their own student population and school community, and then collaborate with colleagues to a) develop interventions that address the teachers' perceptions of the root causes of an educational challenge, b) collect formative data to determine the efficacy of the intervention, and c) reflect with their colleagues on their approach, student outcomes, and how they might modify their intervention to improve their practice. The NIC approach used in research-practitioner partnerships turns the power dynamic of "experts" and "practitioners" on its head by empowering teachers to first develop a deep and authentic understanding of the problem and then by providing teachers with the professional autonomy they need to devise and test out solutions that best meet the needs of their students and community. This sense of empowerment and ownership was evident in the AWSM in CS teacher focus groups. AWSM in CS also offered opportunities for teachers to collaborate together across different schools, districts, and grade levels to address transformational changes that are necessary for broadening participation efforts. This collaborative approach countered the isolation that CS educators often operate under and promoted a vision of teachers as professionals whose influence could and should extend beyond their own classroom. The NIC helped teachers reimagine their own sphere of influence, recognize their own expertise, and take responsibility for making changes to assumptions, norms, policies, and practices with personnel at the school and district level. For many teachers, being a researcher within the NIC was a new experience. Clarifying roles and responsibilities regularly may help them feel more like researchers and may further empower teachers to make systematic changes in their classrooms and as leaders in their districts. The connections among NIC members is one of its greatest strengths, and the organizational structures of the NIC provided opportunities for teachers to feel empowered as they were engaging with and learning about their computer science education practices.

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