

Mentoring Future Mathematics Teachers: Lessons Learned from Four Mentoring Partnerships

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ABSTRACT Mentoring is an important aspect of mathematics teacher education, and in particular, pre-service teacher education. Faculty at a large Midwestern university developed and refined a mentoring program designed to help pre-service secondary mathematics teachers, called Scholars, become future leaders in mathematics education. This paper describes how faculty mentors leveraged challenges in the mentoring program's early stages based on their reflections and initial mentee outcomes to create a more effective mentoring program. Recommendations based on research and practice are provided for other university programs interested in mentoring future mathematics teachers.

KEYWORDS *mathematics education, mentoring, Noyce, pre-service teachers, teacher education*

A significant number of teachers, more than one-third, leave the profession within a few years of beginning in the classroom, especially in STEM fields (Shaw & Newton, 2014). Teachers report factors such as feeling underprepared, overwhelmed, and under-supported as reasons for leaving teaching (Kent, Green, & Feldman, 2012). There is a large body of research that supports the need for a strong mentoring component in teacher education programs and its impact on teacher commitment, retention, and student achievement. Marshall, McGee, McLaren, and Veal (2011) highlighted the impact university faculty members and advisors can play in STEM students' success. In particular, factors such as mentoring and helping students "navigate their programs of study to be congruent with their interests, career preferences, and post-secondary commitments" were emphasized (Marshall et al., 2011, p. 22).

Mentoring programs for students have been utilized in a variety of institutions and in a variety of settings (Orland-Barak, 2014). Overall, strong mentoring programs have been proven to positively impact future student learning of the teachers who participate in the program

and also significantly reduce the attrition rate of new teachers (Ingersoll & Strong, 2011). The mentoring process can positively influence teacher behaviors and classroom practices of novice teachers (Kuzmic, 1994). Additionally, novice teachers who are mentored are more likely to translate their undergraduate learning of empirical-based instructional practice to their classroom teaching (Darling-Hammond, 2000).

Faculty at a large Midwestern university developed a mentoring program for future mathematics teachers as a component of a Noyce teacher recruitment grant, sponsored by the National Science Foundation. The Phase I Noyce Scholarship program built upon ongoing collaborative efforts between the university and local public schools. The main goal of this program was to strengthen and expand the pipeline for preparing mathematics teachers to better meet the demands of local school districts, particularly in high-need schools.

Initially the grant primarily focused on the development of mathematical content and pedagogical knowledge without a mentoring component. Mathematicians and mathematics educators on the faculty leadership

team (FLT) agreed that the addition of mentoring support could be beneficial for program participants. The FLT quickly learned that incorporating mentoring would be a critical, yet complex, facet of the program.

In this paper, a detailed description will be provided that chronicles the development of the mentoring program, including the successes reached and the challenges faced. Effective mentoring programs benefit teacher education programs (Ambrosetti, Knight, & Dekkers, 2014); therefore, the goal of this article is to share the efforts undertaken at our institution to inform and support other mathematicians and mathematics educators who are developing, or want to develop, similar programs to support future teachers.

Setting the Stage

Scholar Selection

At the outset of the grant award, students were recruited to apply for the Noyce scholarship. Students submitted applications indicating their interest in teaching and mathematics, their GPA, and letters of recommendation. Part of the application included a personal essay describing their background, why they were interested in entering the Noyce program, and their future goals as a mathematics teacher in a high-need school. This information served as important data for the mentoring selection process, and again as the process was re-evaluated. Selected students for the scholarship program are referred to as “Noyce Scholars,” but for the purpose of this paper will be called “Scholars.”

Following the initial round of selection, Scholars and the FLT convened to discuss the role of the mentor and the goals of the mentor-Scholar relationship. The initial meeting included answering the following questions: “What does it typically mean to be a mentor?,” “What does it typically mean to be a mentee?,” and “Why are such relationships important in preparing to be a mathematics education leader?” The FLT (all of whom are mentors), additional faculty mentors, and Scholars were all provided a book on mentoring new teachers written by the National Council of Teachers of Mathematics (Zimmerman, Guinee, Fulmore, and Murray, 2009). Originally, Scholars were given choice and autonomy to request a faculty mentor. While the FLT were already engaged faculty mentors, other requested faculty were approached to serve as Scholar mentors. Scholars were paired with at least one faculty mentor from the Mathematics and/or Teacher Education departments. These pairings were made either by request of the Scholar or by appointment.

The Role of Mentors

Each mentor and Scholar partnership was encouraged to develop a professional development plan. Mentors and Scholars were encouraged to meet regularly discuss, refine, and report progress on their professional development plans. In the plan, each Scholar committed to demonstrating leadership in mathematics education by the following actions:

- Participating in a multi-day culturally responsive teaching workshop each semester
- Providing leadership within the University Math Club (e.g., serving on a service learning task force, running Math Student Circles)
- Actively participating in extra-curricular mathematics activities at the university
 - Math Club (meetings with other undergraduate mathematics students)
 - Cool Math Talks (talks about engaging mathematics)
 - Math Student Circles (sessions with middle school students doing fun math)
- Planning and completing, with direction from the faculty mentor, a senior project related to mathematics education (e.g., undergraduate research, poster or conference presentation at a regional conference)

Besides this initial meeting and feedback, there was no other structural support given. Minimal processes were in place to train or on-board incoming mentors. Additionally, there were no mechanisms in place to ensure initial expectations of participation or regularly-scheduled mentor-Scholar meetings were upheld. For some of the mentor-Scholar pairs, “regular” meetings were a weekly or multiple times per week event. Yet for others, meetings occurred face-to-face once per semester with intermittent email communication. Initially, the FLT wanted to avoid micromanaging mentors who were essentially volunteering their time to support Scholars. However, the FLT became aware, mainly through Scholar realizations and complaints, that there were large discrepancies between mentor expectations.

After further investigation and individual meetings with the FLT, it became apparent that Scholars were indeed having extremely different experiences depending on the mentoring they were receiving. For example, the FLT found that one Scholar with infrequent communication with his faculty mentor had minimal experiences or progress towards his twelve hours per week Scholar commitment. He had started a few initiatives, including providing mathematics support for a chemistry class,

but did not follow through on the commitment or sustain his participation. In contrast, another Scholar spent ten hours per week working with the Emerging Leaders Club for predominately Hispanic students at a local high school. This Scholar helped develop college financial plans, engaged students in innovative problem-solving, and organized guest speakers to talk to the students about college preparation and the university mathematics program. While this Scholar's achievements and dedication was stellar, the FLT believed providing a high-quality program with equitable support and high expectations for all Scholars rather than "islands of excellence" was the true goal and mission of the scholarship program and grant expectations.

Mentor Vignettes on Four Initial Scholars

As the first-year mentor-Scholar partnerships continued, challenges with the mentoring program were more and more apparent in individual faculty mentors' reflections and Scholar achievement. Change was absolutely necessary, so the FLT sought to examine the success and challenges of the first year to make informed decisions about programmatic changes in the future.

The following vignettes represent the perceptions of four mentors working with the four originally funded Scholars. The examination of the mentor reflections and Scholar experiences assisted the FLT in evaluating and addressing how to identify issues and work to find resolutions to the mentoring challenges. Each of the Scholar's mentoring experiences taught the FLT valuable lessons to inform not only future practice, but potentially serve other faculty mentorship programs. In particular, each vignette describes the Scholar's background, mentoring experience, and ultimate retention in the Noyce scholarship program.

Scholar Amy

Amy entered the program as a nontraditional Latina. She was pursuing a teaching degree after being at home with young children and then working as a paraprofessional in the public schools. She had experiences working in a dual language program in the public schools and sought to build upon relationships established through that program.

She was paired with a mentor who had served as a professor in a mathematics class. Her mentor encouraged her to work within the building she had familiarity with and to continue to work with students with whom a previous relationship had been established. The mentor met weekly with her, and facilitated Amy's commu-

nications with other Scholars. Through Amy's participation with an emerging leaders' program for Hispanic students in a local high school, Amy not only mentored students, but also engaged other Scholars in the program. The role of the mentor in this case was that of oversight and facilitation. The FLT envisioned mentoring would create opportunities for Scholars to take the lead brainstorming innovative ways to grow as a student and future teacher. This mentor-Scholar relationship demonstrated this student-centered vision. Amy took the lead on a project that was of interest to her, involved other Scholars in the project, met with her mentor regularly for support and guidance, and was consistently involved in the Noyce program in ways that would help her become a better teacher in a high-need school district.

Despite the fact that the leadership team thought of Amy and her mentor as role models for other mentor/mentee pairs, as Amy considered applying for the second year of funding through the Noyce program, issues came to light of which faculty were unaware. The lack of consistency between Scholars' outcomes and participation had caused concerns on both the FLT and some Scholars. In comparison to other Scholars, Amy felt that her mentor had pushed her to do more than the other Scholars already. Entering her second year, Amy became aware of increasing Scholar expectations and decided she did not believe she had adequate time to commit to the program and withdrew.

With better dialogue between the FLT and Amy, it is possible that she could have communicated those concerns earlier on and had positive reinforcements that would have allowed her to participate in the program for the second year. Though Amy still finished her mathematics teacher education program, she did not seek employment as a secondary mathematics teacher. The FLT realized that improved communication and clear guidelines for all mentor/mentee pairs was necessary and may have been influential in retaining Amy in the field.

Scholar Andy

Andy entered the program as an immigrant to the United States of America (USA), only four years earlier. He arrived in the USA as a non-English speaker and was uncertain of his career aspirations or opportunities. Through the guidance of a caring high school teacher, he recognized he was particularly strong in mathematics. After experiencing a positive mentoring relationship in high school, he sought opportunities to be a mentor after entering the University. His initial desire was to be

paired with a Noyce mentor with whom he could establish a friendly, personal relationship, similar to what he had been inspired by in his past. Andy was paired with a mathematics professor who was not part of the FLT, but purely volunteered as a faculty mentor. Andy and his mentor met infrequently and by the conclusion of the first year, there was minimal evidence Andy was supported or developed through his mentoring relationship.

Andy was involved in many Noyce events, yet did not take initiative or a leadership role. There were initial attempts to create a tutoring program for chemistry students struggling with math. Problems surfaced in this endeavor and the project was dropped. Andy attended many outreach events and activities, but indicated he was not often aware of the opportunities that existed. Andy's desire to help and be a part of events at the University and within the community led the leadership team to develop better means of communication among Scholars and mentors regarding activities being organized. These efforts would not only serve as a means to inform Scholars of events, but also to serve as a mechanism to showcase leadership endeavors initiated by the Scholars.

Andy did apply for the Noyce program in the second year, but due to other scholarship funding sources he was unable to receive significant funding. He agreed to participate on a part-time basis as a Noyce Scholar. Hence, he did not benefit as much from the second-year programmatic mentoring changes, as his requirements were minimal during the second year. Andy graduated and is currently employed as a secondary mathematics teacher in a high-need school. Since graduation, Andy has not maintained contact with his original mentor, but has attended professional development opportunities offered by the program.

Scholar Katrin

Katrin became a Noyce Scholar as a traditional student. She had graduated at the top of her class from high school and her parents had encouraged her to pursue a degree in engineering. By the end of her freshman year, it was clear that her passion was mathematics, not engineering, and she switched her major. She enjoyed working with others and therefore declared a double major in mathematics and education once accepted into the Noyce program.

Katrin requested her mentor be an education faculty member, who was a previous instructor for one of her classes. The faculty mentor agreed to the request, but mentoring meetings were inconsistent. Mentor support mechanisms, beyond the FLT mentors, were not clearly

communicated or established to support this mentor/mentee relationship. Unlike Andy, who was self-motivated to participate in any activities made known to the Scholars, Katrin was unengaged from the Noyce program and rarely attended events and activities. The leadership team accepted much of the blame for this situation, as Katrin did not have access to a significant amount of mentoring. It is unclear what contributions Katrin made to the Noyce program and similarly, the impact of Noyce participation on her growth as a student.

Not surprisingly, Katrin decided not to accept a second year of funding from the Noyce program and was uncertain if she would fulfill the obligation to become a mathematics teacher in a high-need school. After initially struggling early in her career and leaving the field, Katrin did eventually return to teaching and continues to teach in a high-need school.

Scholar Stacy

Stacy, like Amy, applied for the Noyce program as a nontraditional student. She had previously earned a graduate degree in health, physical education, and recreation and had been employed in that field as a swim instructor and manager of a pool. She entered the Noyce program with a strong desire to become a high school mathematics teacher, hoping to have a lasting impact on traditionally underserved children.

She requested the assignment of a mentor from the College of Education, and due to the mentor's busy schedule, she was assigned two mentors. A mentor was assigned from the mathematics department, as well as the requested mentor in teacher education. It became clear that the designation of two mentors presented challenges. It was not obvious which requests and suggestions were being given by which mentor, and communication between the mentors did not occur. As a result, a conflict emerged between the student and one of the mentors. The FLT intervened and eventually assigned a different mentor to the student.

On a positive note, the intervention from the leadership team was successful, and taught the team the power of communication in mentoring. Stacy applied for another semester of Noyce funding and was an active Scholar during that time. She is now fulfilling her Noyce obligation by teaching in a high-need school. She has also become a leader at her school and was even invited to present some of her work at an international education conference.

With all of the original Scholars, the FLT noticed a theme of disconnectedness to both faculty mentors and the cohort of Scholars. Each participated in the same

Noyce program; however, each had drastically different experiences from the mentoring perspective. In any case, Andy, Katrin, and Stacy did continue on to teaching and fulfilling their commitment to teach in high-need schools.

Moving Forward with Reform

From each of these vignettes, a great deal was learned about how to better serve future Noyce Scholars. In particular, several changes in the mentoring process were made as a result of lessons learned from the original cohort of Scholars and their respective mentors. These lessons can be used to strengthen other Noyce programs, but in general, these lessons can be applied when mentoring future teachers.

Research to Inform Practice

At the outset of this Noyce teacher recruitment program, an examination of the literature revealed that the success of the mentoring partnerships could be aided by several factors: a) mentor training, b) the careful selection of participants, and c) the need for ongoing evaluations (Ehrich, Hansford, and Tennent, 2004). Barrera, Braley, & Slate (2010) highlight the importance of well-defined goals in mentoring programs interested in retaining beginning teachers in particular. They described difficulties in their mentoring program as including scheduling conflicts, lack of release time, and no guidelines or preparation provided to mentors and mentees. We found similar findings in our Noyce mentoring program as we aimed to prepare pre-service mathematics teachers for high-need school settings.

In the first year of our Noyce program, mentors and mentees were paired either by Scholar request or FLT placement; however, the features of the mentoring relationships, with regard to intent, purpose, intensity, and duration, were not clearly defined (Crisp, Baker, Griffin, Lunsford, & Pifer, 2017; Jacobi, 1991). Inconsistencies were identified in terms of how the expectations of the mentor-Scholar partnerships were defined. This led to mixed outcomes with the initial group of Scholars with regard to retention and participation. Our experiences parallel other studies on the conceptual limitations of mentoring programs (Crisp, et al., 2017). Through the analysis of mentor reflections after the first year, it was clear that the FLT needed to provide additional structures and supports both for mentors and mentees. The goal was to create more targeted and impactful faculty-Scholar interactions (Museus & Neville, 2012) that met

both the professional and personal needs of the Scholars (Jacobi, 1991; Murdock, Stripanovic, & Lucas, 2013) to increase retention of Scholars in the Noyce program.

The main purpose of this paper was to better understand how mentoring can be structured to maximize the potential benefits on undergraduate mathematics education students with regard to promoting academic success and retention. The examination of the individual vignettes revealed problems and successes of the mentoring process, which will be expounded upon in the following section. A critical analysis of past experiences can assist a FLT in being able to learn from issues, resolve them, and create a better program.

Changes in the Mentoring Process

Upon reflection and analysis of the four Scholar experiences and continued mentoring conversations, the FLT identified three main categories of focus for immediate modifications for programmatic improvement and sustainability. These changes were based on research informed best practice of undergraduate mentoring (Zimmerman, Guinee, Fulmore, & Murray, 2009), Scholar feedback, and FLT perceptions based on the needs and goals of the Noyce grant program. Within each category, time and structure were invested to execute a plan for improvement.

Mentoring guidelines established and sustained. There appeared to be a need to establish mentoring guidelines for both the mentors and the Scholars. This would allow for consistency among Scholars as well as provide guidance for new mentors. The first mentoring guideline established focused on mentor-Scholar pairing. While the FLT invited Scholar input on their preferred mentor, they realized that ultimately the successful pairing of supportive mentors should be decided by the leadership team. The FLT must consider Scholar strengths and areas of growth to match each Scholar with a strong, supportive mentor. For example, under new mentoring practices, the FLT intentionally paired an extremely strong mathematics student with minimal teaching experience with a Teacher Education faculty member to provide additional opportunities to work in schools and with children.

Another new mentoring guideline was to create norms for mentoring interactions in terms of frequency and duration. Weekly meetings between each mentor-Scholar pair were to last approximately one hour and provide a forum for open dialogue to occur, addressing not only the ongoing Noyce projects, but also the academic progress and social-emotional well-being of the

Scholar. With weekly meetings, mentors have been more aware and available to support Scholars who navigate busy schedules and take heavy and challenging course loads.

Communication outlets. To sustain the new mentoring guidelines, the FLT now has a variety of outlets to communicate with both mentors and Scholars about the mentoring component expectations. Along with weekly mentor-Scholar meetings, each semester mentors are invited to attend a lunch where faculty update the group on their Scholar projects, share best practices in goal setting and mentorship, and reiterate mentor and Scholar expectations. Additionally, mentors and Scholars are invited to a breakfast at the start of each semester where expectations are shared to ensure all parties hear the common vision and goals of the program.

In addition to regularly scheduled meetings, the FLT created an online communication outlet within the pre-existing campus learning management system to centralize all Noyce communication, announcements, documents and protocols, and activity calendars. All mentors and Scholars have access to upcoming events and expectations in a familiar and frequently utilized campus tool.

Consistency and accountability. Based on the initial four Scholars, it became apparent to the FLT that developing high, consistent expectations for all participants was extremely important. Mentoring was the key link to ensure that Scholars were all striving towards the same target of excellence as they prepared for a career in teaching mathematics. In their reflective journals, scholars collaboratively shared (in an online discussion board) their weekly hours and implications their Noyce activities may have on their future as a teacher and/or mathematician. They list their accomplishments and their challenges each week. Mentors could readily view what the Scholars had written and Scholars became aware of what their peers were doing. The added level of positive peer pressure to the requirements has resulted in a substantial increase in Scholar participation and completion of weekly journaling. For mentors who sometimes struggle to brainstorm collaborative activities with their Scholar, the shared space provides a great resource of project ideas.

In terms of the collaborative mentor-Scholar projects, Scholars are each expected to lead a major project one time per year. These projects are often designed and implemented with their mentors. Being clear on this expectation has led to many important developments in-

cluding teaching assistantships, undergraduate research projects and articles, community STEM outreach events, conference presentations, and large-scale mathematics events for local high school students. Being purposeful with our mentor-Scholar pairing has also honored faculty mentors who volunteer their time and talents. Both faculty and Scholars can be successful when all parties find mutually beneficial aspects to the relationship.

Conclusions and Future Directions

The lessons learned provoked the establishment of more consistent guidelines, communication, and accountability. In turn, Scholars have shared that collaborating with their mentors and members of the FLT has increased their confidence speaking to “authority/superiors” and also prompted them to take on more leadership responsibilities where they would need to “speak up more and take charge of my ideas.” Noyce Scholars share how working with faculty has increased their own perception of their professionalism. With increased leadership expectations reiterated by their mentors and other faculty, our Scholars have been exposed to snippets of diverse experiences intended to strengthen their knowledge and skills as mathematicians and future teachers.

The programmatic changes to mentoring have made a substantial difference in the consistency and implementation of the program as it has continued to grow. Mentoring literature (e.g., Ambrosetti et al., 2014) and critical reflection on our past experiences permitted the FLT to review and revise our practices for increased retention of both Scholars and also our faculty mentors. Of the 12 students who have graduated from our institution and participated in the Noyce program, 11 earned their teaching certification and are fulfilling their commitment to teach mathematics in high-need schools. Developing a deeper connection with faculty and their cohort of peers has resulted in a more collective and collaborative community of learners. Unlike the experiences of Amy, Andy, Katrin, and Stacy, our program, driven by strong mentoring relationships, has become more cohesive and focused.

The Noyce scholarship program continues to develop. Our preliminary research serves to inform future efforts to study the impact of our mentoring program on Scholars over time. The FLT has a deliberate focus on guiding new faculty mentors and members of the Noyce leadership team with clear goals and expectations. As faculty, we continue to recognize how our continued collaboration and willingness to take risks as life-long learners is making an impact on our student Scholars.

We continue to believe and practice that modeling adaptive and reflective behavior will benefit our Scholars as future classroom teachers as they grow dedicated practitioners and leaders themselves. We hope our lessons learned in researching our mentoring program will serve other universities and mentoring programs.

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