
Finding their Voice: Support Mechanisms to Engage and Empower Future Mathematics Teachers¹

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Abstract

The NebraskaMATH Omaha Noyce Partnership Scholarship awards scholarships funded by the National Science Foundation (NSF) to undergraduate students interested in mathematics education at the University of Nebraska at Omaha (UNO). Scholars, who are dual mathematics and secondary education majors, are engaged and supported by Noyce faculty to not only excel in their college coursework and career preparation, but also to serve the university and community through teaching assistantships and STEM community outreach. The main goal of this program is to strengthen and expand the pipeline for preparing high-quality teachers of mathematics to better meet the responsibilities and demands of local school districts, particularly those serving students with high-need. Cross-campus collaborations between the departments of teacher education and mathematics co-constructed the Noyce infrastructure to emphasize and share the development of future, high-quality secondary mathematics teachers (Mathematics Teacher Education Partnership, 2014). This paper describes our program's unique design and implementation features aimed to empower, engage, and extend the talents of our undergraduate students. We share lessons learned and recommendations from faculty and participants regarding decisions and facets of the program considered to be most influential in STEM teacher and leadership development.

Introduction

At the national level, the focus on what it means to effectively teach high school mathematics is shifting (NCTM, 2018). Teachers are expected to collaborate with one another on instructional issues to provide high-quality, engaging learning experiences for all students (NCTM, 2014). University teacher preparation programs and mathematics departments must develop pre-service teachers who not only understand current research-informed instructional practices, but also who have first-hand experiences learning, teaching, and collaborating in student-centered environments (CBMS, 2016). This framework begs the question: Beyond undergraduate coursework and coordinated field experiences, what other components of teacher preparation support pre-service teachers to thrive as mathematicians, teachers, and leaders?

This paper describes unique features of our NSF-funded Robert Noyce Teacher Scholarship grant (DUE-1439796). The grant's purpose is to empower, engage, and extend the learning experiences for dual major pre-service mathematics and secondary education teachers. We will discuss the overall project infrastructure and underlying benefits of engaging pre-service teachers with leadership opportunities in a variety of diverse teaching

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and learning environments. Furthermore, this paper includes lessons learned and recommendations from the participants and from faculty. These lessons lead to programmatic changes and activities that have been instrumental in developing engaged and empowered pre-service teacher leaders.

Background

In 2013, the NSF awarded UNO with a Phase I Robert Noyce Teacher Scholarship Program grant. The aim of the grant was to address the growing concern that the United States is not producing enough science, technology, engineering, and mathematics (STEM) professionals for the needs of our nation, especially as compared to many other countries around the world (Ingersoll & Perda, 2010). This diminishing STEM competitiveness directly threatens our economy. The instruction of mathematics is of special concern, since it is often at the foundation of learning other STEM disciplines.

Within this context of concern for national competitiveness in STEM, school districts across the country (especially those in areas with at-risk student populations) are finding it increasingly difficult to fill mathematics teacher vacancies with qualified candidates. Vacancies for mathematics teachers in Omaha, Nebraska, mirror these national trends.

The NebraskaMATH Omaha Noyce Partnership, our Phase I Noyce Teacher Scholarship Program that is now in its fourth year, continues to build upon ongoing collaborative efforts between UNO and the Omaha Public Schools (OPS), to strengthen and expand the pipeline for preparing mathematics teachers at UNO. In particular, the partnership aims to better meet the high demand for STEM teachers in local school districts, especially those at-risk student populations. The Omaha Noyce Partnership is an initiative that aligns with NebraskaMATH, a statewide partnership, led by the University of Nebraska–Lincoln (UNL) that works to improve achievement in mathematics for all students and to narrow achievement gaps of at-risk populations. The program, which includes new coursework and complements the existing pathways in the College of Education, was developed by the UNO mathematics and education faculty in collaboration with school district partners. The goal of the program is to develop highly skilled secondary mathematics teachers who are committed to teaching in high-need schools by providing targeted support for students enrolled in and graduating from the mathematics/teacher preparation program. By *highly skilled*, we mean future teachers who will be strong in both mathematical and pedagogical content knowledge, as well as leadership skills that also will allow them to further build strong mathematics programs within their schools.

Program Structure

Participants

We have two types of program participants: (a) Noyce Scholars, undergraduate juniors or seniors, on full scholarship for a dual major; and (b) Noyce Interns, freshman through juniors, who are: paid hourly, potentially interested in mathematics and/or education, and are actively exploring the option of mathematics education as a career. All Noyce Interns (freshman or sophomores) are academically eligible and/or on track to pursue the Noyce scholarship. Unlike Scholars, Interns are paid as hourly workers, from \$12 to \$15 per hour, with several lump sum payments during the year. Due to the less formal commitment to a future career as a secondary mathematics teacher, approximately half of our Interns pursue their original STEM major or non-dual mathematics/education major. Table 1 shows the number of Scholars funded through our Noyce program since 2015.

Requirements

The Omaha Noyce Partnership program is designed to develop highly skilled secondary mathematics teachers who are committed to teaching in high need schools, defined as schools where more than 50 percent of

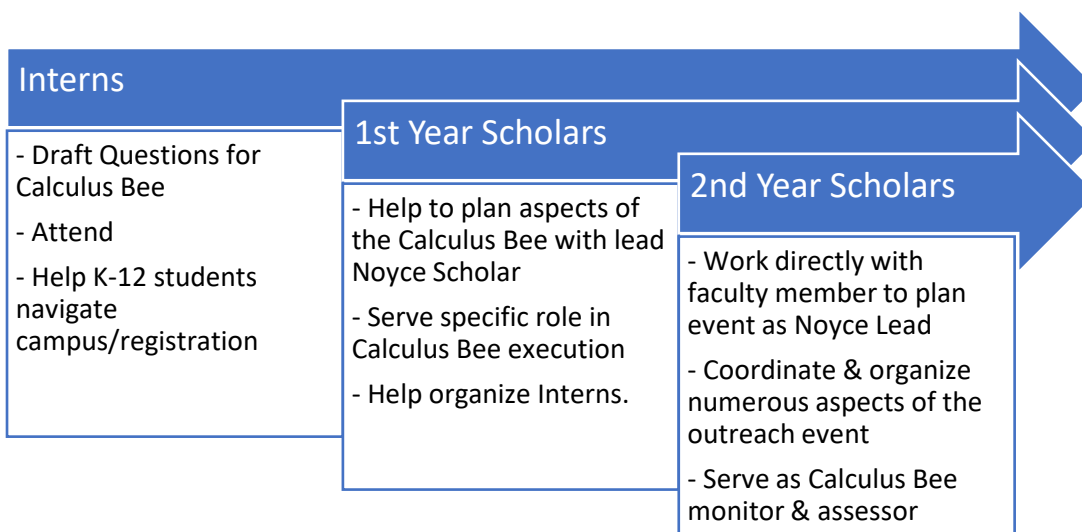
students receive free or reduced lunch. This definition is not limited to schools in Nebraska. One Scholar-graduate is completing her Noyce obligation with a school district in Ohio, her home state. Our Scholars are required to obtain employment in said schools for a minimum of two to four years, depending on the amount of scholarship received (up to \$16,000 per year), to fulfill the expectations of the Noyce scholarship program. If they opt not to teach or to do so in a high needs school, then the scholarship automatically becomes a student loan with repayment structures.

Table 1

Number of Scholars Funded, by year, in NebraskaMATH Omaha Noyce

Year	Number of 1 st -Year Scholars	Number of 2 nd -Year Scholars	Total Scholars
2015	4	0	4
	1 of the first-year Scholars did not apply for a second year of funding but did graduate with a teaching certificate and has fulfilled her teaching requirements.		
2016	4	3	7
	1 of the first-year Scholars was a senior and graduated.		
	1 of the second-year Scholars graduated but is not yet fulfilling her teaching requirements and will have to start repayment soon.		
2017	6	3	9
	All 6 first-year Scholars returned in 2018.		
2018	4	6	1
	2 of the first-year Scholars put their college career on hold for personal reasons.		
	1 of the first-year Scholars dropped out of the program to pursue a full mathematics degree.		
	1 of the second-year Scholars put her college career on hold because of a pregnancy and will graduate in 2020.		
	1 of the second-year Scholars will student teach Fall 2019.		
2019	6	1	7
Total Scholarships:			24

UNO's longstanding partnership with OPS plays an important role in helping our Noyce graduates locate full-time teaching assignments that fulfill their scholarship requirement. Both mathematics and teacher education faculty from UNO work closely with our partners in OPS. To date, all 11 dual-degree completed Noyce participants are grant compliant, working in high-need schools as first, second, or upcoming third year teachers, which aligns



with the first and third of the MTE-Partnership's *Guiding Principles for Secondary Mathematics Teacher Preparation Programs* (2014).

Figure 1. Example of trajectory of involvement in outreach from Interns to second-year Scholars.

Over the course of our program, the hours and expectations for Scholars and Interns have evolved based upon periodic program review and recruitment considerations. Currently, Scholars and Interns dedicate approximately 12 and 8 hours per week, respectively, to Noyce-related activities. Such activities include, but are not limited to, a regular mentoring-meeting with faculty, serving as a teaching assistant, coordinating outreach activities, tutoring mathematics students, attending professional development, and meeting with their Noyce peers. We intentionally provide a variety of activities designed to build on the individual talents and skills of our Scholars and Interns so that they each have tailored leadership and instructional experiences. Scholars and Interns are required to reflect in weekly online journals on their engagement hours related to their development as a mathematician, teacher, and/or teacher leader. Figure 1 diagrams how Interns and Scholars, at a variety of levels, are engaged in one particular outreach event, a Calculus Bee for 900 high school students.

Translating our Mission into Practice

Teaching is a complex task and involves a variety of considerations and experiences to expose pre-service candidates to the realities and opportunities of their future career responsibilities. Dunlap and Hansen-Thomas (2011) found that when pre-service teachers engaged in targeted leadership experiences and were supported by faculty mentors, their self-efficacy increased. The authors suggested that novice teachers need to learn how to seek out experienced mentors, professional development opportunities, opportunities to network, and ways to take on leadership roles in their field to develop this self-efficacy over time.

The overarching mission statement of our Noyce program is to create better mathematicians, better teachers, and better leaders. Over time, our Noyce leadership team has operationalized how our program design aims to ensure our Scholars and Interns gain knowledge, skills, and professionalism through participation in our program. To achieve our program goals and mission, the Noyce faculty leadership team established avenues to leverage research on pre-service teacher development to empower, engage, and extend the learning experiences of our undergraduate Scholars and Interns.

Empowerment

Empowerment, in relation to teachers, occurs when teachers are given autonomy, gain knowledge, and see improved status in their field (Farrell & Weitman, 2007). Within the context of pre-service teacher preparation, we aim to empower our Noyce participants similarly. As faculty leaders we provide structure, without micromanaging. This supported autonomy ensures our Noyce participants have the opportunity to gain efficacy in their own abilities, accomplishments, and grow where they see there is the most need. To do so, we have integrated mentoring, active learning, and professional development experiences into the fabric of our program for all participating Noyce undergraduate students.

Mentoring. Mentoring within teacher education programs has been widely studied and supported by research based on its impact on teacher commitment, retention, and student achievement. University faculty members and advisors are identified as key players in STEM students' success (Marshall et al., 2011). 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).

Early in the grant, mentoring quickly surfaced as a crucial programmatic component to ensure Scholars and Interns were supported and retained in our program and the field. Faculty identified the need for very intentional and consistent mentorship of Scholars and Interns. Despite initial mentoring challenges, which included difficulty in getting mentors and mentees routinely together, over time the faculty mentor-mentee relationships have solidified to weekly contacts and empowered Noyce Scholars and Interns in not only their career goals, but also in navigating personal and academic success. Scholars and interns share that collaborating with their mentors and other Noyce leadership faculty 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.” For instance, Noyce Scholars have presented at local, regional, and national conferences alongside Noyce faculty and their peers. They share how their Noyce experience has increased both their confidence speaking in front of others and also their perception of themselves as a professional. One Scholar stated, “I gained a voice and the confidence to speak to superiors as well as peers especially if there was something that wasn't right or that I needed to be successful.”

Active learning experiences. Research suggests that coherent teacher development programs dedicated to active learning and focused on content knowledge result in positive effects on teacher practice (Garet et al., 1999). Noyce participants are encouraged to take courses taught by faculty, many of whom are Noyce mentors, who incorporate Inquiry-based Learning (IBL) instructional practices into their courses. In these IBL mathematics courses, students present problems, engage in collaborative group work and discussions, and experiment in hands-on, active learning environments (Ernst, Hodge, & Yoshinobu, 2017), which aligns with Guiding Principle 4 (MTE-Partnership, 2014). This environment aligns with best practices of mathematics teaching and learning (NCTM, 2014) taught within the teacher preparation program and therefore, serves as a model for Noyce Scholars’ future classrooms. One participant said, “I now tend to speak up more and take charge of my ideas. I am also way more confident in jumping up in front of a class as well.” These types of experiences as a learner can be powerful later as they develop more dispositions as teachers.

Noyce Scholars and Interns also actively participate in professional development training on concepts that are immediately relevant to their Noyce opportunities and degree program requirements. In particular, all Scholars and Interns actively participate in a required culturally responsive teaching (CRT) two-part seminar. CRT is a framework through which teachers learn to adapt curriculum in ways that create bridges between the communities and cultural identities of traditionally marginalized students (Ladson-Billings, 1995). Within these trainings, Noyce Scholars and Interns learn ways to bring their students’ experiences into the mathematics classroom and the community, as asked in Guiding Principle 5 (MTE-Partnership, 2014). Noyce participants are able to immediately apply their professional, active learning opportunities to Noyce-related activities providing heightened meaning and empowerment as future teacher practitioners. CRT pedagogy embodies the necessary knowledge, skills, and disposition required of our Noyce Scholars and Interns who regularly work with diverse communities and students through outreach and other STEM programming.

Engagement

Scholars and Interns are actively engaged in authentic learning and teaching experiences related to mathematics. Our program provides a network of support including structured peer interactions, faculty mentoring in teacher education and mathematics, K–12 school district teachers, and other STEM-affiliated community members (e.g., non-profit directors, STEM coordinators). The primary network is the Omaha Citywide STEM Ecosystem, which is a community organization now over two years old, that engages more than 80 city organizations (including 13 public school districts) and has over 750 members who attend many different sessions and community events. One of just 58 citywide STEM Ecosystems as recognized by the STEM Funders Network, this organization has a full-time director that is a UNO-employee based at the Zoo. It offers many different

engagement points for our Scholars and Interns, such as popular community-based teaching circles like Mathematics with an Architect, Mathematics with an Engineer, Mathematics with a Chef, and Mathematics at the Aquarium. Each of these teaching circle sessions are presented by community organizations, such as businesses, museums, and informal education organizations.

Teaching and service. UNO's traditional pre-service teacher trajectory includes over 150 hours of supervised field experiences within the teacher education program, but any additional teaching or service-learning opportunities are optional and not part of the formal programming in the College of Education. Unlike traditional secondary mathematics education students, Noyce Scholars and Interns have the opportunity to work with faculty as teaching assistants in IBL mathematics courses (Calculus and beyond). Over time, interested mathematics faculty now request Noyce participants, and some are even recruited into the program by faculty hoping to further engage students in the application of mathematical content through teaching. These experiences are unique to our participants in comparison to the traditional mathematics education programming on campus.

Scholars and Interns also help to coach and tutor students studying for the Praxis Core, a required exam for students entering formal programs in the UNO College of Education. Serving as a teaching assistant and peer tutor in mathematics are mutually beneficial engagement activities for all involved. Scholars and Interns are able to develop their mathematical and communication skills while having a tremendous impact on their UNO peers. In particular, the Praxis study group has been growing in attendance over the past year with an increase in students' Praxis mathematics scores after participating regularly in the tutoring sessions. In addition, the success of the program for helping elementary education majors is impressive, with the ability for the study group to help a student not only pass the Praxis, but also to do quite well on it. For example, one student started with two consecutive scores of 130, and then raised their score to 168 after study group participation, greatly exceeding the 150 cutoff score.

Community outreach. Another feature of the Noyce program that differs from traditional pre-service mathematics educational programming is that Noyce Scholars and Interns have numerous opportunities to lead STEM outreach events on campus, at local schools, and throughout the community. On campus, Noyce participants host one to two Student Math Circles per semester. The events are designed for Grades 6–12 students to use critical thinking and problem solving in mathematics while experiencing a college campus environment. The Scholars and Interns plan, coordinate, market, and facilitate events from start to finish with the guidance of faculty mentor support. These outreach events provide Noyce participants opportunities to engage with community partners beyond a structured classroom-based field experience and helps them to develop connections and experience with developing and hosting future outreach events of their own. One Scholar noted,

The Omaha Noyce program has helped me develop my leadership skills among the group throughout the semester. For example, by the end of the semester I was able to volunteer to lead an activity/project and gather a group to help me with that project very easily. It has also become easier for me to reach out to people in the community and offer outreach ideas or assistance with outreach.

Our Noyce program also partners with Omaha Girls Inc., a national non-profit organization that focuses on supporting the academic, socio-emotional, and physical health of girls and young women, to offer a four-week summer STEM camp for 60 middle school girls each year. Noyce Interns work as instructional assistants during the camp and even lead mathematics and STEM-related sessions. They interact with students of diverse backgrounds and educational settings to provide instructional support and ultimately develop and teach their own STEM activities with the girls (also Guiding Principle 5).

Extension

Over the past five years, the Noyce leadership team has continuously reflected and responded to our programmatic and support structures to consider how we offer unique and enriching experiences and opportunities beyond the standard degree-program requirements. Through engagement and empowerment, we strive to not only recruit and retain participants in our program, but also to extend their network and capacity as 21st century STEM professionals.

Community of learners. Little (2002) describes a *community of learners* as a structured collaboration of teachers to critically examine aspects of their teaching practice, investigate alternative “conceptions of teaching and learning,” and support one another’s continued professional growth (p. 918). A major focus of the Noyce leadership team has been to help our Scholars and Interns develop as an active and robust community of learners while they are in our program. Communities do not always evolve naturally, and we found that some intentional structure was necessary for Scholars and Interns to collaborate regularly, both with faculty and one another, to develop a shared vision and mutually beneficial collaboration for participants’ academic and professional growth.

Noyce participants meet with their mentor weekly and also hold a Scholar-led meeting each week where they plan upcoming events, participate in professional development and hear from speakers, and/or form study groups aligned to their mathematics coursework. Our intentional focus on community building has created a more consistent and quality experience for all of our Noyce Interns and Scholars. Instead of “isolated islands of excellence” based on each participant or mentor’s experience or personality, the interconnected teaching, learning, and outreach has resulted in a more communal level of achievement, productivity, professionalism, and motivation (Guiding Principle 6).

Reflective practice. In education, the practice of reflection is viewed as an important and even critical mechanism through which teachers can examine and refine their teaching beliefs and practices (Schon, 1983). Isik-Ercan and Perkins (2017) suggest that effective teacher reflection includes reflection on meaning and on action. In our program, we incorporated a range of structures to help our Scholars and Interns reflect on their experiences and their beliefs about STEM teaching and learning.

Each week, Noyce participants create and post written reflections in three key parts: description, analysis, and implications. Beyond summarizing and justifying their weekly hours, Scholars and Interns use their reflections to grapple with their experiences in an open forum with other Scholars and Interns. Scholars and Interns are able to reflect with mentors in weekly meetings, yet also have the support of their peers within the online collaborative space. One Scholar shared her experience as a learning assistant in a Calculus course,

That was the first time I had knowingly been in in an IBL classroom so it was cool to see how it ran. I love how you can actively watch the learning happen, and I was very intrigued by some of the discussions that took place.

Scholars and Interns are able to learn from and reflect upon how their peers interpret similar or different Noyce opportunities from their perspectives (Guiding Principle 6). After transferring our weekly reflections to the collaborative Canvas learning management platform, reflection completion rates increased to 92.5% (112 out of 121) during the last semester with little to no mentor interventions.

Discussion and Implications

During the first three years of our grant, the Noyce faculty leadership team attempted to find effective ways to operationalize our mission of creating better mathematicians, better teachers, and better leaders. We developed structures and opportunities to support our Scholars and Interns in becoming empowered future

teachers and engaged and collaborative community members, and have attempted to extend these supports beyond their time as undergraduates and into their teaching practice.

Throughout their reflections and surveys, Scholars identified confidence, professionalism, and the ability to speak up and to superiors as leadership skills they have acquired through their Noyce participation. Beyond the traditional teacher preparation program experience of their non-Noyce peers, our Scholars have explicit experiences in the classroom, community, and on-campus, examining their ability to be teacher leaders. One Scholar expressed “being more comfortable stepping out of my comfort zone, which is an important part of being a leader.” Another Scholar provided a holistic picture at how the Noyce program impacted him,

The program has given me connections with people that I never imagined meeting, it’s made me closer to the faculty and I’ve gotten to know the math/education department a lot better. As previously mentioned, it has also helped me develop leadership skills through experiences I wouldn’t have otherwise. All the outreach events and meetings I feel make me a lot more prepared than I could ever be without the Noyce program.

Our collaborative leadership team has learned, through feedback and continuous refinement, the importance of developing structured mentoring relationships, offering professional development that is timely and relevant to the needs of our Scholars and Interns, and providing opportunities for them to engage with one another and other community stakeholders. It became very evident that ongoing reflection and program evaluation was critical in helping us to refine these supports in order to actively engage and retain Scholars and Interns over time. Through this reflection process, we made adjustments to our mentoring structures to ensure participants had consistent support from an engaged faculty member. We created weekly meetings to facilitate collegial relationships among student participants and developed a distributed leadership model by which Scholars helped to coach and mentor new Interns to address some of our programmatic challenges. Although we have made several such adjustments to said structures, we are still looking ahead for ways to be as intentional in the extension phase of our project, and we hope to learn more as additional Scholars and Interns graduate and begin their teaching careers. It is our hope that other teacher preparation programs can learn from the model presented in this paper and also hope to continue dialogue and research into how to effectively train future STEM educators and leaders.

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