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An Integrated Model for STEM Teacher Preparation: The Value of a Teaching Cooperative Educational Experience

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Abstract

The purpose of this article is to evaluate an intensive, integrated model for teacher preparation, specifically, a preservice STEM teacher education model which incorporates science or mathematics content with pedagogical content knowledge in an early, intensive classroom immersion program based entirely in a local school. STEM preservice teachers participated in a cooperative teaching experience which placed them at the school site for their university course work and field placements, thus ensuring a more seamless connection between theory and practice. The findings from this comparative study of the STEM preservice students in the teaching co-op and STEM preservice teachers in a traditional preparation model indicate that the STEM preservice teachers in the teaching cooperative model were more confident about their teaching skills, more comfortable with their content knowledge, and prepared to work effectively with high-needs students.

Keywords: STEM teacher preparation; Teacher education

Literature Review

To be effective in their practice, teachers of science, technology, engineering, and mathematics (STEM) must have deep knowledge of the content that they teach (Darling-Hammond, 1999; Munby, Russell, & Martin, 2001; Shulman, 1986; Wilson, 2011). Additionally, they must also have specialized knowledge of how to teach STEM content to students—i.e., pedagogical content knowledge (Shulman, 1987). To effectively impart both content and pedagogical knowledge, Grossman, Hammerness, and McDonald (2009) urge teacher preparation programs to dismantle the "divide between foundations and methods courses, as well as the separation between the university and schools" (p. 273). The purpose of this article is to evaluate an intensive, integrated model for teacher preparation, specifically, a preservice STEM teacher education model which incorporates science or mathematics content with pedagogical content knowledge in an early, intensive classroom immersion program based entirely in a local school.

Background

Content Knowledge

According to the National Research Council (2000), "content knowledge must be a central focus of a science or mathematics teacher's preparation, with the result being a deeper understanding of the fundamental science, mathematics, or technology that he or she will need to teach" (p. 4).

A report from the President's Council of Advisors on Science and Technology (2010) noted that "28 percent of the U.S. public school teachers who are teaching science in grades 7-12 lack a minor or major in the sciences or science education" (p. 61). More than one quarter of our middle and high school science teachers do not possess this deep content knowledge or the requisite skills in teaching STEM content and may not meet the minimum teaching qualifications in the sciences (p. 61).

In a study of K–5 teachers, Nadelson et al. (2013) found that teachers' knowledge of STEM content was positively correlated with both efficacy for and confidence in teaching STEM for the 32 participants in their Year 2 cohort (p. 162). Surprisingly, the second cohort's efficacy and confidence with STEM were not correlated with years of teaching experience (Nadelson et al., 2013, p. 162), indicating that experience alone does not account for improvement in either efficacy or confidence with STEM teaching.

Lee and Houseal (2003) noted that the primary internal impediment to science teachers' self-efficacy was a lack of science content knowledge (p. 50). Overall, self-efficacy toward science teaching, or the belief in one's ability to teach science, encompasses the teacher's comfort level, self-confidence, and attitude about teaching science (p. 39). Lee and Houseal suggested that teachers with high self-efficacy are more likely to engage in group work and activity-based teaching with their students as they use their science content knowledge to guide instruction. They noted that teachers with higher levels of self-efficacy "are much more independent and resourceful science teachers . . . . They are the least dependent on a textbook" because they have strong science content knowledge (p. 52). High self-efficacy allows teachers to address classroom management issues and adapt to changes in content standards. Teachers with lower self-efficacy, or limited science content knowledge, were only able to engage in student-centered or project-oriented lessons for select topics with which they had prior experience; teachers with higher self-efficacy were more likely to engage in such lessons regularly, even for content with which they were less familiar (p. 53).

Pedagogical Content Knowledge

Successful STEM teaching demands pedagogical content knowledge, the ability to effectively communicate STEM concepts in a way that students can understand. The President's Council of Advisors on Science and Technology (2010) argued that teachers must "have strong pedagogical training specific to STEM" (p. 59). Similarly, the "standards from the Interstate New Teacher Assessment and Support Consortium (INTASC, 1999) . . . [assert] that teachers of science and mathematics need to understand content as well as know how to apply that content in problem-solving and inquiry-based situations in the classroom" (National Research Council, 2000, p. 57). "Ball (1998) contended that, to teach mathematics effectively, a teacher must have knowledge of mathematics and a conceptual understanding of the principles underlying its topics, rules, and definitions" (p. 59); the same could be said about all STEM subjects. This conceptual understanding, together with practical experience in the classroom, helps build the necessary content-oriented pedagogical knowledge of a successful STEM teacher. The President's Council of Advisors on Science and Technology (2010) suggests that teachers with these proficiencies are able to "explain concepts and procedures from multiple perspectives, . . . make their subjects come alive . . . make STEM relevant . . . deal with questions from inquisitive students and, in turn, pose challenging questions to their students . . . ignite student interest in STEM . . . encourage students to question assumptions, rather than accepting what they are told as a given . . . and inspire and motivate students to study STEM" (p. 59–60). Unfortunately, this content-oriented pedagogical expertise is the most difficult to impart to preservice teachers, due in part to the prevalence of "content-free methods courses, emphasizing general strategies rather than specific instructional responses to address specific student ideas in a specific topical area" (National Task Force on Teacher Education in Physics, 2010, p. 5). One motivation for developing the integrated STEM teacher preparation program presented in this article was the desire of faculty members from education, arts and sciences, and engineering to develop a model that would directly integrate STEM content with pedagogical course work.

Partnership Between STEM and Education Departments to Prepare Preservice STEM Teachers

To address the gap in pedagogical content knowledge, the National Academy of Sciences envisioned that "SME&T [STEM] faculties would assume greater responsibility for the pre-service and in-service education of K-12 teachers" (National Research Council, 1999, p. 7). The National Academy of Sciences encourages partnerships between college-level STEM and education departments to assist preservice teachers in acquiring the necessary content knowledge, pedagogical knowledge, and pedagogical content knowledge. Specialized college departments tend to hinder preservice teachers in acquiring the pedagogical content knowledge required for acquiring skills in inquiry and activity-based STEM teaching practices because they present their course work in distinct and separate programs. The National Academy of Sciences suggests that, due to departmental isolation, STEM faculty may be unaware of best practices in STEM pedagogical education. Likewise, education faculty may not be knowledgeable about current scientific research. Therefore, collaboration between STEM and education faculty is necessary to ensure that new STEM teachers are effectively prepared (National Research Council, 1999, p. 43). According to the National Research Council (2000), STEM departments "should assume greater responsibility for offering college-level courses that provide teachers with strong exposure to appropriate content and that model the kinds of pedagogical approaches appropriate for teaching that content" (p. 11–12).

An Integrated STEM Teacher Preparation Model

The Robert Noyce Teacher Scholarship Program administered by the National Science Foundation (NSF) provides grants to higher education institutions to develop innovative STEM teacher preparation programs that will recruit and prepare STEM professionals and preservice teachers for the teaching profession (American Association for the Advancement of Science, 2015). With support from NSF and the Robert Noyce Teacher Scholarship program, faculty in the Colleges of Education, Engineering, and Arts and Sciences at this private, midwestern university initiated a unique undergraduate STEM teacher preparation program in 2009. The purpose of the program was to adapt the cooperative education model used to prepare engineers and applying it to STEM teacher preparation.

Cooperative education combines academic study with practical work experience. Engineering co-op students typically alternate semesters of school attendance with semesters of industry placement. They complete a minimum of three alternating work terms with their co-op employer, which extends their undergraduate program to 5 years. By the end of the their program, they will have gained 12–16 months of relevant work experience. The Robert Noyce Teacher Scholarship Program discussed in this article is an extrapolation of this engineering industry co-op model. The placements for the teaching co-op model were held in high-needs, urban, middle and high school settings and involved extensive educational field experiences that allowed undergraduates to meet their university and state teacher education standards (van den Kieboom, McNew-Birren, Eckman, & Silver-Thorn, 2014).

The Noyce STEM Scholar Program included three STEM teaching co-ops. The first teaching co-op occurred during the students' junior year and was a full immersion experience at a high-needs secondary school. The students completed nine credits of education coursework at the high school site where they were also assigned to specific mathematics or science classrooms. The high school provided space for the university class that was led by a university instructor, access to the science and mathematics classrooms, and mentorship from classroom teachers. The second teaching co-op took place during the students' fourth year and included course work and a placement at another high-needs school. The course work and experiences of this second co-op focused on the pedagogical content knowledge that the scholars needed to become effective STEM teachers by linking the mathematics or science methods course to a middle school methods course while providing direct practice at the school site. The third and final teaching co-op consisted of the traditional student teaching semester, which involved full-time placement and teaching at a third high school, direct work with a STEM classroom teacher, and participation in a university seminar.

In this article, we focus on the first of the three STEM teaching co-op experiences for the Noyce STEM Scholar Program and examine the experiences of the undergraduates who participated in that program from 2010 to 2013.

Methods

Setting for the STEM Teaching Co-Op

The secondary school that partnered with the university on this project is located approximately five miles from the university in an ethnically diverse neighborhood. It is a relatively small public high school (200 students) recently established by the public school district as a charter school with a focus on science and mathematics for children from Spanish speaking backgrounds. The high school principal graciously made space available for the STEM teaching co-op experience, assisted in integrating the Noyce scholars into the school setting, and provided access to classroom teachers. The scholars were present in the school with the university instructor for 2 full days of school (or 3 half days of school, depending on scholars' schedules). For the remainder of the week, the undergraduate students completed additional requisite course work at the university. While at the high school, the Noyce scholars participated in university course instruction, observed and worked in high school science and mathematics classrooms, attended professional development programs with the school's faculty, tutored students in study halls, and assisted teachers with STEM course development.

This STEM teaching co-op experience was designed to prepare preservice teachers by addressing pedagogical content knowledge in an integrated format, providing opportunities for reflection and development as a teacher. The university course included topics on learning and assessment, differentiated instruction for exceptional learners, and literacy in the content areas. Assignments for the course were designed to integrate these theoretical concepts with practical experiences (Grossman et al., 2009). For instance, the Noyce scholars were required to maintain journals in which they reflected on the general high school class environments, content presentations, classroom management techniques, and ways that individual learning needs were met. The scholars contrasted their observations with theory and discussions from their pedagogical course instruction. Other assignments included writing a lesson plan that included differentiated instruction, conducting interviews of faculty and students at the high school, and identifying professional STEM teaching resources for future use.

Data Collection

Data collected for this study included responses to surveys, course assignments, and field experience journals from the four cohorts of scholars who participated in this STEM teaching co-op from 2010–2013. To investigate the effects of the teaching co-op experience, survey data were acquired from both the Noyce STEM scholars (n = 10) and undergraduate students with comparable academic degree programs in the traditional STEM teacher preparation program (n = 6) at this university. Interviews and focus group sessions were conducted with teachers in the collaborating high school who had interacted with the scholars; these individuals also had prior experience with traditionally prepared STEM preservice teachers. The university instructor for the first teaching co-op was interviewed to further assess the effects of the teaching co-op model on STEM teacher preparation and student development. All study procedures were reviewed and approved by the university's Institutional Review Board (protocols HS-1826 and HS-2345). Written informed consent was solicited and obtained from all students prior to research participation.

The survey instrument was adapted from a senior exit survey used by the College of Education at the university to assess the effectiveness of the traditional teacher preparation program. The specific survey items are summarized in Table 1. The survey instrument was distributed to the Noyce STEM scholars and comparable-level peers who participated in the traditional STEM teacher preparation program at the same point in their respective programs. Students were asked to respond on a 4-point Likert scale: *strongly agree* (4) to *strongly disagree* (1). Respondents were also asked five open-ended questions regarding the strengths and weaknesses of their respective STEM teacher preparation program, the features most and least helpful for their growth and preparation, the experiences outside classes and field work that were helpful in their growth and preparation, and suggestions for improving the STEM teacher preparation program. *T*-tests were conducted to assess differences between the Noyce scholars and the traditionally prepared student groups.

Qualitative data from the open-ended survey questions, the teaching co-op assignments and the field experience journals were analyzed and coded in order to identify common themes that paralleled the survey concepts. Open coding and iterative cycles (Strauss & Corbin, 1998) were used to analyze the interviews (Bogdan & Biklen, 1998).

Findings

Both the Noyce STEM scholars and their traditionally prepared STEM peers reported that the teaching co-op or their comparable three discrete courses and related field experiences prepared them well in several aspects of classroom teaching (see Table 2). The self-assessment scores reported by the Noyce STEM scholars, however, often exceeded that of their peers. Specifically, these self-reports indicated that the Noyce STEM scholars were better prepared than their peers in four areas: (Q1) understanding the central concepts of mathematics or science, (Q4) understanding how to provide for differences in students' approaches, (Q5) providing instruction to support all students, and (Q7) understanding the barriers that can impede student learning. These specific findings will be presented and discussed in further detail with supporting data collected from the interviews, focus groups, and the open-ended comparative survey questions.

Table 1
Items From the Survey on Teacher Preparation Program Effectiveness

Q1:	To understand the **central concepts**, tools for inquiry, way of reasoning, uncertainties, and controversies in the content areas I will teach.
Q2:	To create **learning experiences** that make the subject matter I teach meaningful for students.
Q3:	To understand how **children** with broad ranges of ability learn and **develop**.
Q4:	To provide instruction that supports all students' intellectual, social, and personal development. (**developmentally appropriate instruction**)
Q5:	To understand how students differ in their approaches to learning and to **differentiate instruction** to meet the diverse cognitive, cultural, racial, linguistic, and physical needs of all students.
Q6:	To understand the role of culture in learning and to provide culturally relevant/**culturally responsive instruction**.
Q7:	To understand the societal and **structural barriers** that can impede student learning and to work to reform those structural inequities.
Q8:	To understand and use a variety of **instructional strategies** to encourage children's development of critical and creative thinking, problem solving, and performance skills.
Q9:	To use an understanding of individual and group motivation and behavior to create a **positive learning environment**.
Q10:	To encourage positive social interaction, **active engagement** in learning, and self-motivation.
Q11:	To use effective verbal and nonverbal **communication techniques** to foster active inquiry, collaboration, and supportive interaction in my classroom.
Q12:	To organize and plan **systematic instruction** based upon knowledge of subject matter, students, and community and curriculum goals.
Q13:	To use formal and informal **assessment strategies** to guide instruction and to provide me with information necessary to differentiate instruction to meet the learning needs of all students in my classroom.
Q14:	To be a **reflective practitioner** who continually evaluates the effect of my choices and actions on students, parents, professionals in the learning community and others.
Q15:	To actively seek out opportunities to **grow professionally**.
Q16:	To **collaborate** with school colleagues, parents, and agencies in the larger community to support student learning and well being.
Q17:	To serve as **advocates for marginalized students** and for individual students whose needs are not being addressed by the school.

Note. Bolded items highlight the respective primary concepts

Table 2
Comparison of Survey Data from Noyce STEM scholars (n = 10) and Traditional STEM students (n = 6)

					95% Confidence Interval of Difference	
	Mean	*SD*	*t*-value	Significance (2-tailed)	Lower	Upper
Q1: Central Concepts	**0.40**	**0.16**	**2.45**	**0.037**	**0.031**	**0.769**
Q2: Meaningful Learning Experiences	0.33	0.24	1.41	0.181	-0.176	0.843
Q3: Child Development	0.20	0.25	0.79	0.446	-0.349	0.749
Q4: Developmentally Appropriate Instruction	**0.50**	**0.17**	**3.00**	**0.015**	**0.123**	**0.877**
Q5: Differentiated Instruction	**0.63**	**0.22**	**2.94**	**0.011**	**0.172**	**1.095**
Q6: Culturally Responsive Teaching	0.25	0.30	0.84	0.414	-0.387	0.887
Q7: Structural Barriers and Inequalities	**0.50**	**0.17**	**3.00**	**0.015**	**0.123**	**0.877**
Q8: Variety of Instruction	0.00	0.34	0.00	1.000	-0.725	0.725
Q9: Positive Learning Environment.	-0.08	0.28	-0.30	0.766	-0.672	0.506
Q10: Active Engagement	0.38	0.34	1.13	0.278	-0.345	1.112
Q11: Effective Communication	-0.41	0.34	-1.21	0.246	-1.137	0.317
Q12: Systematic Instruction	-0.10	0.27	-0.37	0.719	-0.685	0.485
Q13: Assessment Strategies	-0.50	0.34	-1.49	0.161	-1.226	0.226
Q14: Reflective practitioner	0.47	0.24	1.98	0.068	-0.040	0.974
Q15: Professional Development	0.43	0.36	1.21	0.246	-0.335	1.201
Q16: Collaboration	0.50	0.39	1.28	0.221	-0.337	1.337
Q17: Student Advocacy	0.07	0.33	0.20	0.843	-0.642	0.775

Note. Bolded entries reflect statistically significant differences at the 0.05 level.

Understanding of STEM Content

The Noyce scholars were more likely than their traditionally prepared counterparts to agree that they “understand the central concepts, tools for inquiry, ways of reasoning, uncertainties, and controversies in the content areas I will teach” (Q1, $t = 2.45$, $p < 0.037$). The self-reported understanding of the central concepts of the STEM fields occurred despite both student groups being enrolled in the same STEM content courses. The sole difference in the Noyce STEM teacher preparation was the enhanced integration of the STEM content and pedagogical content knowledge during their first teaching co-op experience.

In their open-ended responses to the survey questions, both the traditionally prepared preservice teachers and the Noyce scholars mentioned that the fieldwork experiences were strengths of their educational program. When asked to describe the weaknesses they saw in their preparation, four of the six traditionally prepared preservice teachers expressed frustration that content and pedagogy were taught separately, leading to a disconnect between their content knowledge and their pedagogical knowledge (Grossman et al., 2009). None of the Noyce scholars identified such a disconnect.

The university instructor for the first teaching co-op confirmed the effectiveness of the model when she described the Noyce scholars as "focused, professional, and near classroom ready." The finding that the Noyce scholars were "more classroom ready" than their traditionally trained peers appears to result from the unique structure of the first teaching co-op, which incorporates early, intensive field placements alongside educational methods course content. In the co-op structure, the preservice students were actively engaged in doing the work of practice that Grossman et al. (2009) identified as essential for preparing teachers. The university instructor stressed that this early school immersion was "critical to putting content into context." The structure of the teaching co-op allowed students to apply what they were learning in class directly to their experiences in the field and enabled them to use their field experiences to deepen their understanding of their course work. The Noyce scholars moved seamlessly between their education course work in the high school building to their direct work with students and teachers in the classrooms at the high school. The university instructor felt that the progress the Noyce scholars made as preservice teachers during their first teaching co-op was "better than expected."

Providing Instructional Support to All Students

The Noyce scholars were more likely than their traditionally prepared counterparts to state that they were prepared to "provide instruction that supports all students' intellectual, social, and personal development" (Q4, $t = 3.00$, $p < 0.015$). The Noyce scholars described how they benefited from regular contact with a specific group of high school students and became more comfortable with the school culture and environment. They explained that they felt "more connected" and were able to draw upon the relationships they developed with the students when it came time for them to teach their own lessons. The scholars reflected on the importance of reliability, relationships, and rapport in classroom management and were able to recognize the presence or absence of these relationships and how they affected classroom dynamics. One scholar pointed out a useful approach he saw a cooperating teacher use: "She talks to her students as they enter, and it makes the class have a real personal feel, and makes students feel like their teacher is relatable." Another scholar commented on the result of not fostering relationships with students: "The relationship between pupil and teacher is a very important tool in maintaining good classroom management. With the lack of a relationship, some students find it easier to disobey and ignore the requests of the teacher because they feel that there will be no consequences." It is clear from these reflections that the Noyce scholars have developed pedagogical content knowledge in the teaching co-op model.

Understanding Developmental Theory and Providing Differentiated Instruction

Noyce scholars were more likely than their traditionally prepared peers to indicate that they were prepared to "understand how students differ in their approaches to learning and to differentiate instruction to meet the diverse cognitive, cultural, racial, linguistic, and physical needs of all students" (Q5, $t = 2.94$, $p < 0.011$). The integrated structure of the teaching co-op allowed scholars to learn about teaching and child development theory and immediately see its application in the classroom during their observations at their host high school. Scholars were particularly attuned to how differentiation in the classroom allowed teachers to account for the theory of multiple intelligences. One Noyce scholar made the following observation:

> Seeing Mr. [Teacher] incorporate different learning styles into his lesson plans really helped further my understanding of how to address the multiple learning styles of

> students . . . . Mr. [Teacher] demonstrated how to include activities and parts of a lesson plan that address all different types of learning styles. He used labs to help the kinesthetic learners, diagrams in his lecture slides for the visual learners, and both group and individual work/practice problems for the interpersonal and intrapersonal learners.

Another scholar found lab time to be integral for addressing students' STEM needs: "What I like most about a lab is that it can involve multiple intelligences, engaging a wide range of learners with just one activity." This scholar went on to connect lab work, not only to Gardner's (1983) theory of multiple intelligences but also to Dewey's (1933) authentic learning experience.

Understanding the Structural Barriers to Student Learning

The Noyce scholars were more likely than their traditionally prepared peers to indicate that they understood "the societal and structural barriers that can impede student learning and to work to reform those structural inequities" (Q7, $t = 3.00$, $p < 0.015$). The Noyce scholars' responses to the open-ended questions revealed their attention to issues surrounding the diverse racial and linguistic needs of their high school students. Six of 10 Noyce scholar respondents noted an appreciation for the diversity of the student body at their school. This attention to diversity was reinforced in one scholar's reflections: "I was impressed because the dominant attitude toward urban education is that it is destined to fail, and it was refreshing to see—and participate in—a counterexample." Three scholars mentioned that they were fortunate to work with students with diverse learning needs, including special education students. Another scholar noted, "The thing that I am most concerned about is being able to meet the various needs of all my students."

This first STEM teaching co-op placed the Noyce scholars in a predominantly Hispanic urban high school. As such, the scholars became aware of the difficulties English language learners face when learning new content in an unfamiliar language. One scholar commented on the language barriers between him and a Spanish-speaking student with whom he was working on a regular basis. The scholar found it difficult to communicate mathematics concepts to the student and noted, "One thing I noticed from my day with [the student] was that it was easier for her to understand my examples by looking at them compared to me explaining to her what I did . . . . Therefore, it was important that I provide clear examples that demonstrated the proper techniques."

Reflective Practitioners

Another difference between traditionally trained preservice STEM teachers and Noyce scholars appears in response to the statement "I feel prepared to be a reflective practitioner who continually evaluates the effect of my choices and actions on students, parents, professionals in the learning community, and others" (Q14, $t = 1.98$, $p = 0.068$). Noyce scholars were more comfortable with reflective practices and articulated the value of taking the time to reflect on their practices and experiences.

The Noyce scholars recognized that the structure of the teaching co-op had positively affected them. They explained that over the course of the semester they went through a transformation from a "college student" to a "teacher." One scholar stated, "I have gotten more confidence in what I can do and my teaching ability . . . . I'm beginning to see myself more as a prospective teacher than as a student in college." After reviewing his earlier journal entries, he expressed surprise at his own progress. "At the beginning I wrote from the perspective of either a learner or an observer, and as time went on I began to assume the role of a teacher . . . . I became more comfortable seeing myself as a teacher." This transformation is noteworthy because it took place over a single semester, during the first of three STEM teaching co-op experiences.

Many of the Noyce scholars expressed their concerns with classroom management in their reflections and discussed "both the good and the not-so-good" teachers they had observed. In these reflections, scholars noted teaching practices that they hoped to avoid and those they aspired to adopt. One scholar commented on an example of an unsatisfactory teacher: "I believe the majority of the problems was in [the teacher's] approach with the classroom." The scholar went on to explain what he would have done differently and why that alternative strategy might be more effective.

Limitations

There were several limitations to this study, primarily the small sample sizes for the Noyce scholars ($n = 10$) and the traditionally prepared students in STEM fields that formed the comparison group ($n = 6$). Additionally, the focus group findings were collected as written summaries rather than as formal transcriptions. Changes in the university instructor for the teaching co-op experience meant that there were some changes in the assignments and assessments used between the first (2010) and later cohorts (2011–2013).

Conclusion

Despite these limitations, it is clear that there are important differences between the traditional STEM teacher preparation program and the Noyce STEM Scholar Program's first teaching co-op, which had integrated theory and practice (Grossman et al., 2009) to strengthen scholars' pedagogical content knowledge of the theories of learning and adolescent development with direct observation and practice in the field. The Noyce scholars came away from this integrated teaching co-op experience with stronger pedagogical content knowledge, as evidenced by their appreciation and understanding of the needs of students with different learning abilities and racial and linguistic backgrounds. Having spent 2 full days or 3 half days at the high school throughout the semester, either in their university classroom or working directly with the high school students in STEM classrooms, the scholars gained a level of self-confidence and self-efficacy that they brought to the remainder of their teacher preparation program.

The strong pedagogical content foundation and the scholars' resulting comfort in the classroom did not go unnoticed. When these scholars became student teachers in the third STEM teaching co-op, their cooperating teachers commented on their level of confidence. The teachers noted that the scholars were more comfortable with both the content and with high school students than their traditionally prepared preservice teacher counterparts were. This confidence likely contributed to the increased independence noted for the Noyce scholars when compared to traditionally prepared students. Like all new student teachers, the Noyce scholars were initially hesitant to engage students in dialogue; however, according to their cooperating teachers, the scholars became comfortable in initiating discussions more quickly than did traditionally prepared student teachers. Cooperating teachers characterized the Noyce scholars as more flexible, ambitious, interactive, open to constructive criticism, involved, eager, competent, and prepared than many traditionally prepared students with whom they had worked.

This article focused on the first of three STEM teaching cooperative experiences for Noyce scholars. The results support the continuation and further development of this model for both STEM teacher preparation and teacher preparation for other content areas. As Grossman et al. (2009) argue, there is a clear advantage for university preservice teachers when they are able to closely and almost seamlessly integrate educational theory and practice in their courses and field placements. Being in a single school setting for both course work and field placement better prepared the Noyce scholars, making them comfortable with their content knowledge and how to effectively work with high-needs students. Further studies that compare the strengths of the teaching co-op model for the entire teacher preparation program, inclusive of the three teaching co-op experiences, are needed.

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