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STEM Teachers in Highest-Need Schools:
An Analysis of the Effects of the Robert Noyce Teacher Scholarship Program on STEM Teacher Placement and Retention

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Abstract: In addition to the state's expansive pool of Noyce recipients, Texas' long-established and robust public school administrative data system provides a rare opportunity to examine the placement and mobility of STEM teachers in the public school system. Because of the large concentration of low-income students in the state, this study of Texas teachers is able to uniquely contribute to the literature base regarding the placement and retention of STEM teachers by examining highest-need schools—those with populations of at least 75% low-income students. Restricting the study to examine highest-need schools provides relevant information to address the national STEM teaching shortage, as the number of low-income students increases each year. Relying on a conceptual framework of teacher pathways to the profession this study is guided by the following research question: To what extent does participation in Noyce programming influence the placement of first-year STEM teachers and the retention of early-career STEM teachers at the highest-need schools?

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STEM Teachers in Highest-Need Schools: An Analysis of the Effects of the Robert Noyce Teacher Scholarship Program on STEM Teacher Placement and Retention

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Introduction

Well established in the field of education research is the influence of teacher quality on both short- and long-term student outcomes (Ashton, 1984; Chetty et al., 2014; Darling-Hammond, 2000; Hanushek, 2011; Rivkin et al., 2005; Rockoff, 2004; Stronge et al., 2011). Despite the important role that educators play, the country is experiencing a nationwide teacher shortage as school districts face difficulties filling staffing needs in the classroom (Sutcher et al., 2016). Mathematics and science teachers are in particular demand (Dee & Goldhaber, 2017); data from the U.S. Department of Education (2015) demonstrates the need to increase the number of educators in the disciplines of science, technology, engineering, and mathematics (STEM). During the 2015–2016 school year, more than 40 states reported teacher shortages in mathematics and science (Sutcher et al., 2016), and researchers say this shortage has the potential to drastically impact the nation's capacity to advance technological innovation (McConnell, 2017; Sutcher et al., 2016).

Furthermore, the STEM-related teacher shortage is often exacerbated in schools serving higher proportions of low-income students, as those schools generally maintain higher rates of teacher attrition and increased teacher mobility (Boyd et al., 2008; Ingersoll, 2004; Simon & Johnson, 2015). Teachers placed in high-poverty schools often leave for advancement opportunities and increased salaries or more lucrative reward structures (Guarino et al., 2006), greater support from school leadership and a more inclusive culture (Simon & Johnson, 2015; Sutcher et al., 2016), or improved working conditions (Johnson et al., 2012).

In an effort to increase the number of STEM teachers and improve their retention—specifically in schools with the highest needs—the National Science Foundation (NSF) in 2002 created the Robert Noyce Teacher Scholarship Program, which encourages STEM students and professionals to pursue teaching roles in "high-need educational local educational agencies" (National Science Foundation, 2017; U.S. Department of Education, 2015). Borrowed from the Higher Education Act of 1965, the term "high-need educational local educational agency" is defined by NSF as a school with a high percentage of students from low-income families, a high percentage of educators teaching outside their certification area, or high teacher turnover rates (National Science Foundation, 2017). In alignment with the program's mission, Noyce recipients are provided with teacher preparation support through a variety of mechanisms. In exchange for a commitment to teach in high-need school districts for at least two years post-graduation, STEM students gain access to scholarships and internship opportunities aimed at facilitating their path toward becoming STEM educators.

Texas is among the many states experiencing a STEM teacher shortage. With a public school population of 60% low-income students, Texas has been working to reverse this two-decade shortage by implementing more than 30 Noyce programs (Center for Research, Evaluation, & Advancement of Teacher Education, 2015; National Science Foundation, 2017).

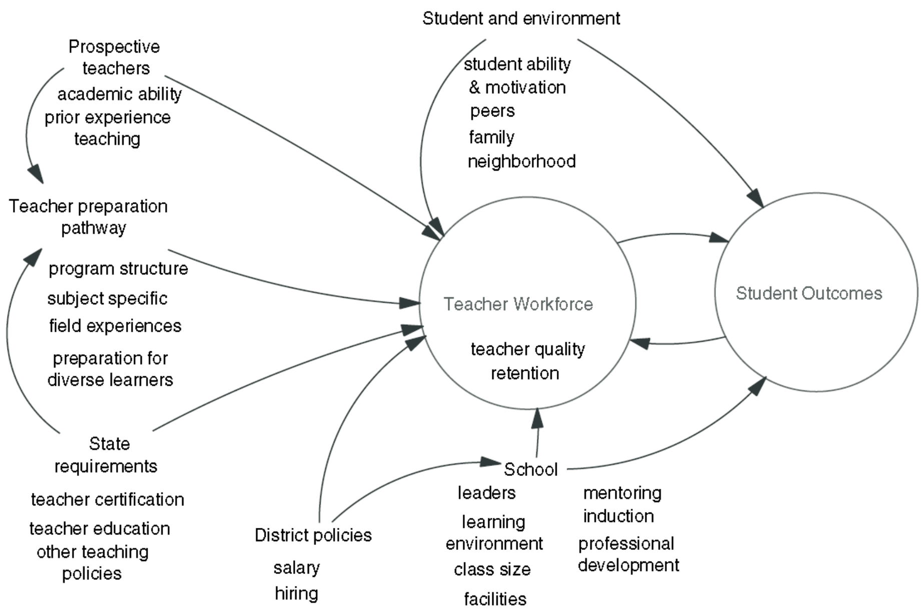
In addition to the state's expansive pool of Noyce recipients, Texas' long-established and robust public school administrative data system provides a rare opportunity to examine the placement and mobility of STEM teachers in the public school system. Because of the large concentration of low-income students in the state, this study of Texas teachers is able to uniquely contribute to the literature base regarding the placement and retention of STEM teachers by examining highest-need schools—those with populations of at least 75% low-income students. Restricting the study to examine highest-need schools provides relevant information to address the national STEM teaching shortage, as the number of low-income students increases each year (Texas Education Agency, 2010; 2018). Relying on a conceptual framework of teacher pathways to the profession (Boyd et al., 2006), this study is guided by the following research question: To what extent does participation in Noyce programming influence the placement of first-year STEM teachers and the retention of early-career STEM teachers at the highest-need schools?

Conceptual Framework

Boyd et al. (2006) demonstrate the complexities of preparation and placement of the teacher workforce in their conceptual framework of teacher pathways to the profession (Figure 1).

Figure 1

Conceptual Framework of Teacher Pathways to the Profession



Source. Boyd et al. (2006), p. 159

The Noyce program is situated in the "teacher preparation pathway" component of Figure 1 as a mechanism to influence prospective STEM teachers into the profession and provide high-quality preparation programming. While the framework provides an opportunity to study teacher placement in the highest-need schools, additional literature must be considered in order to also study *retention* at the highest-need schools.

The vast body of literature encompassing research on first-year and early-career teacher retention highlights a complex network of factors—most notably school and student demographic and economic characteristics—that influence the decisions of teachers to stay in the profession (e.g., Cochran-Smith, 2004; Boyd et al., 2011; Ingersoll et al., 2014; Loeb et al., 2005; Papay et al., 2017; Boyd et al., 2008; Feng & Sass, 2017). School characteristics such as campus leadership, climate, and culture are key factors associated with teacher retention (Harris & Sass, 2011; Johnson et al., 2012; Kraft et al., 2016; Loeb et al., 2005). Djonko-Moore (2016) provides evidence of how climate variables that reflect teachers' beliefs about students of color and low-income students also are related to mobility patterns. Further research reveals how teachers' leaving patterns in many of the nation's neediest schools are often less associated with the students they teach but rather the conditions of school leadership (e.g., principal effectiveness) and various facets of school culture (e.g., norms of trust and respect) (Grissom, 2011; Simon & Johnson, 2015).

Student characteristics such as race and socioeconomic status have also been linked to teacher staying patterns, as retention is demonstrably lower in schools that serve large numbers of low-income and racially minoritized students (Darling-Hammond, 2010; Ingersol, 2001; 2004; Papay et al., 2017 Simon & Johnson, 2015). Prior investigations have found that student discipline as well as the absence of motivation also influence teachers' decisions to leave (Borman & Dowling, 2006; Brill & McCartney, 2008; Ingersoll, 2001; Ingersoll & Smith, 2003), and schools with lower student achievement and lower engagement from parents are also less likely to retain teachers (Borman & Dowling, 2006; Boyd et al., 2006; Guarino et al., 2006). Furthermore, some teachers report they are unprepared to deal with the challenges related to meeting the elevated needs of students in higher-need settings (Darling-Hammond, 2010), making them more likely to depart.

In sum, extending the scope of Boyd et al.'s (2006) original teacher preparation and placement framework to include teacher retention and bring specific focus to highest-need schools provides the analytical lens through which the effects of Noyce programming for STEM teachers in Texas can be examined. Grounded in the academic literature regarding teacher placement and retention, the analysis is further contextualized by the specific literature regarding STEM teachers and previous analyses of the effects of Noyce programming.

Review of Literature

The United States faces persistent shortages of STEM educators in high-need fields such as chemistry, physics, and computer science (Ingersoll, 1999; Hutchison, 2012; U.S. Department of Education, 2015), creating what researchers have described as an impending crisis with the potential to drastically impact the nation's capacity to increase mathematics and science literacy and advance technological innovation (National Academy of Sciences, 2006; McConnell, 2017; Sutcher et al., 2016). Such trends are also visible at campuses with higher economic needs (Yang, 2015). As a result of the teacher shortages, many of those teaching in the STEM content areas are doing so without certification or preparation (Hough, 2000), often relying on temporary certifications to teach year to year (Abell et al., 2006).

Investigations into the cause of the STEM teacher shortage identified concerns with both recruitment and retention. Recruitment into teaching programs suffered from a lack of awareness and understanding of both university-based initial STEM certification programs

(Hutchison, 2012) and alternative certification programs for professionals seeking career change (Darling-Hammond & McLaughlin, 1995; Ingersoll & Smith, 2003). In response, STEM researchers and practitioners developed interventions aimed at facilitating ease of access among students and professionals interested in teaching these subjects. University-based recruitment initiatives such as New Jersey STEM Pathways, STEM Teach in Indiana, and EnCorps' summer internship programs in California and Colorado were designed to provide additional pathways into teaching, especially for participants from underrepresented racial and gender groups (Brown et al., 2020; Lenaburg et al., 2012). An additional example, the SMAR^{2}T: Science and Mathematics Academy for the Recruitment and Retention of Teachers is an NSF-sponsored program for alternative certification of science and mathematics teachers (Abell et al., 2006).

Another challenge rather unique to STEM teach recruitment is the deep learning in content and pedagogy necessary for STEM classroom success. Substantial content knowledge and requisite skill in science, technology, engineering, and mathematics have been positively linked to self-efficacy and confidence in teaching (Lee & Houseal, 2003; Menon & Sadler, 2016; Nadelson et al., 2013). Further, stakeholders in this area have noted that STEM educators must develop deep pedagogical knowledge of how to facilitate learning in STEM disciplines (Eckman et al., 2016; President's Council of Advisors on Science and Technology, 2010). Finding teachers with substantial content knowledge in highly specific areas and the pedagogical training to facilitate STEM classrooms has proven difficult, as demonstrated by the fact that many science and mathematics teachers do not hold degrees in STEM-related fields (President's Council of Advisors on Science and Technology, 2010).

To address challenges with pedagogy and content knowledge, the National Academy of Sciences (2006) encourages collaborations between STEM departments and education departments to build out cross-disciplinary strategies that support preservice teachers in gaining the content knowledge and pedagogical skills needed to successfully teach in STEM-related classrooms. One example is the UTeach Institute founded by the University of Texas, a multi-campus network of teacher preparation programs that aim to grow the population of well-prepared secondary STEM educators. The UTeach model is designed to close the gaps between education teacher pedagogy-based courses and STEM major courses by facilitating dual enrollment for students seeking certification (UTeach, 2020). Another example can be found in the Noyce Foundation, which for years funded a cross-college STEM teacher preparation model designed to mimic an engineering industry co-op model that generated higher levels of confidence, greater comfortability with content knowledge, and more confidence in teaching abilities—including with the skills needed to teach students in high-need settings—among STEM preservice teachers (Eckman et al., 2016).

In addition to the specific challenges of STEM teacher recruitment, STEM teacher retention has been shown to be lower than other fields of teaching (Sutcher et al., 2016). Similarly affected by the known factors contributing to teacher retention generally, including job satisfaction, age, and leadership, Suárez and Wright (2019) have found STEM teacher retention to be distinctively affected by dissatisfaction with the lack of autonomy that has accompanied the high stakes testing environment of the 21st century and leadership majoring in STEM. Moreover, Wang, Chen, Luo, Li, and Waxman, (2018) suggest that STEM teachers' focus on content delivery exacerbate the influence of student behavior on retention. Though not extensively documented, the factors contributing to decreased STEM teacher retention compound the STEM teacher shortage problem.

Prior Research on the Robert Noyce Teacher Scholarship Program

The Robert Noyce Teacher Scholarship Program examined in this research was designed to increase the number of quality STEM teachers in high-need schools by providing scholarships and programming to STEM undergraduate students. Though sparse, published academic literature related to Noyce highlights a limited influence. Prior qualitative investigations found Noyce scholarship requirements to influence placement of students in high-need schools (Kirchhoff & Lawrenz, 2011; Liou et al., 2010; Morrell and Salomone, 2017; Ticknor et al., 2017), though had less of an impact on retention of teachers in high-needs schools beyond the two-year commitment (Liou et al., 2010). Those students that successfully transitioned into and remained teaching in high-needs schools often cited faculty and peer support systems (Kirchhoff & Lawrenz, 2011; Ticknor et al., 2017), the development of their own positive self-view of themselves as STEM teachers (Bischoff et al., 2014) and the scholarships' financial support (Morrell and Salomone, 2017; Ticknor et al., 2017) as critical success factors. The programs' direct influence in increasing the pool of future teachers was minimal, as Noyce recipients typically have already decided to pursue teaching roles upon entrance to the program (Liou et al., 2010; Ticknor et al., 2017). However, one exploration of a program partially supported through Noyce was found to influence mathematics and science majors to consider teaching through undergraduate teacher education program redesign (Scott, et al., 2006).

While these findings offer insight into the effectiveness of Noyce programming, further empirical work is needed to gain understanding into the impact of the NSF-funded scholarship program on teacher recruitment and retention at the highest-need schools. Specifically, in relation to the severity of the STEM teacher shortage in Texas and the high concentration of low-income students, the field would greatly benefit from better understanding the influence of

Noyce programming on STEM teachers serving marginalized students in highest-need schools within the state.

Data and Methods

Texas presents a prime opportunity to examine the placement of first-year STEM teachers and the retention of early career STEM teachers in highest-need schools. In 2018, Texas was home to more than half a million low-income students, many of them attending one of the 3,438 highest-need schools, which serve at least 75% low-income students (Texas Education Agency, 2018). The sheer number of highest-need schools in Texas, coupled with access to statewide administrative data, provides the opportunity to examine the influence of Noyce participation on teacher placement and retention in schools most in need of highly effective STEM teachers.

Dataset Construction

The data for this project primarily derive from a state-level administrative data repository of teacher preparation, certification, and teaching. Combined with the identification of Noyce scholarship or stipend recipients from four participating public institutions in Texas, a teacher dataset was created so individuals could be followed from preparation through school placement. The four participating universities identified 169 teachers who were Noyce scholarship recipients between 2010 and 2018. Because this research sought to understand the influence of Noyce program participation on STEM teacher recruitment and retention, a dataset inclusive of the Noyce recipients was constructed. The dataset for this study captured all individuals who were recommended for initial teaching certification from one of the four participating universities and taught at least one STEM course[1] at a middle school, high school, or mixed grade level school[2] for at least one school year between 2010 and 2018 (N=948).

Preparation

The four participating public universities serving as certifying institutions for teachers in the dataset varied in classification, size, location, and student population served. Two of the universities are quite similar, as they each are located in urban areas, are classified as research universities in the Carnegie Classification of Institutions of Higher Education[3], are classified as Hispanic-Serving Institutions,[4] and serve roughly 35,000 students per year (labeled Urban R1-1 and Urban R1-2). Another Hispanic-Serving Institution in the sample is located in an urban area and is an open-access public university offering bachelor's and master's degrees to more than 14,000 students each year (labeled Urban Open Access). The final participating university is a doctoral degree-granting institution serving about 12,000 students each year in a rural area of the state (labeled Rural Doctoral).

Table 1 displays key Noyce program characteristics of each participating university. The Noyce program was first awarded at Urban R1-1 and Urban R1-2 in 2008 and 2009, respectively, both programs focus on undergraduate and post-baccalaureate teachers from the math, chemistry, physics, biology, and geology disciplines. Noyce programming was initially

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[1] STEM courses included Aerospace Aviation; Agricultural Science; Agricultural Science and Technology Education; Agriculture, Food, and Natural Resources; Biology; Chemistry; Computer Science; Earth Science; General Science; Health Science; Health Science Technology; Information Technology; Mathematics; Physical Science; Physics; Science; Science, Technology, Engineering, and Mathematics; and Technology Education.
[2] While the Noyce scholarship allows for elementary school teachers, only two out of the total 169 at the four universities examined taught in an elementary school (grades K-5). To construct the most accurate comparable dataset, the dataset was limited to participants teaching in a middle school (grades 6-8), high school (grades 9-12), or mixed grade level school (grade levels spanning two or more categories: elementary, middle, high).
[3] The Carnegie Classification of Institutions of Higher Education (n.d.). About Carnegie Classification. Retrieved from http://carnegieclassifications.iu.edu/
[4] Hispanic Association of Colleges and Universities, Hispanic-Serving Institutions, 2018-2019. Retrieved from https://www.hacu.net/images/hacu/OPAI/HACU%20LIST%20OF%20HSIs%202018-19.pdf

awarded at Urban Open Access in 2011 and focuses on developing undergraduate mathematics teachers. Rural Doctoral was first awarded the Noyce program in 2009 and focuses on undergraduate and post-baccalaureate teachers in math, chemistry, physics, biology, geology disciplines.

Table 1

Key Noyce Program Characteristics of Participating Universities

	Discipline Focus	Program Level	Year Initially Awarded
Urban R1-1	Math, Chemistry, Physics, Biology, Geology	Undergrad, Post-Baccalaureate	2008
Urban R1-2	Math, Chemistry, Physics, Biology, Geology	Undergrad, Post-Baccalaureate	2009
Urban Open Access	Math	Undergrad	2011
Rural Doctoral	Math, Chemistry, Physics, Biology, Geology	Undergrad, Post-Baccalaureate	2009

Table 2 displays the number and racial and ethnic composition of teachers from each participating university. The largest number of teachers in the dataset (449) were recommended for certification through the Urban R1-1 university, where 39% identified as white, 27% as Hispanic, 19% as Asian, 13% as African American, 1% as Native American, and 1% as two or more races. The second research university (Urban R1-2) in the study recommended 208 teachers in the dataset for certification who were more white (59%) and less minority than the first research university. The Urban Open Access institution recommended the smallest number of teachers for certification in the dataset (55) and had the highest percentage of non-white teachers (69%). The Rural Doctoral university recommended for certification 236 mostly white (84%) teachers in the dataset.

Table 2

Racial and Ethnic Composition of Teachers Per University, 2010–2018

	Total Participants	African American	Asian	Hispanic	Native American	Two or More Races	White
Urban R1-1	449	13%	19%	27%	1%	1%	39%
Urban R1-2	208	6%	9%	24%	0%	2%	59%
Urban Open Access	55	15%	9%	40%	2%	4%	31%
Rural Doctoral	236	7%	0%	6%	0%	2%	84%
Total	948	10%	12%	22%	0.40%	2%	54%

The teacher dataset for this study included 167 of the original 169 identified Noyce scholarship or stipend recipient teachers. Two were removed from the original dataset as they were those who taught at an elementary school in their first year of teaching. This small number and the increased retention typically demonstrated at elementary schools (Hughes, 2012) required they be dropped from the dataset. Table 3 shows the number of Noyce recipients and the teachers who make up the comparison group for this study from each university.

Table 3

Noyce and Non-Noyce Recipients Per University, 2010–2018

	Noyce Recipients		Non-Noyce Recipients		Total
	#	%	#	%	#
Urban R1-1	48	11%	401	89%	449
Urban R1-2	92	44%	116	56%	208
Urban Open Access	13	24%	42	76%	55
Rural Doctoral	14	6%	222	94%	236
Total	167	18%	781	82%	948

In total, 18% of teachers in the dataset were Noyce recipients, but the distribution among participating universities was not consistent. At the Urban R1-2 university, 44% of teachers in the dataset were Noyce recipients. Noyce participation was least at the Rural Doctoral university, where only 6% of teachers in the dataset were Noyce recipients. The variance in Noyce participation is due to differences in grant intent and specifications (Evans et al., 2019).

Certification

The Noyce program requires recipients to obtain a certification in the field of mathematics or science. Table 4 shows the number of teachers by initial certification area and Noyce program participation. The table shows that 350 of the 781 non-Noyce teachers in the dataset and 107 of the 167 Noyce recipients in the dataset received an initial certification in mathematics. The Noyce recipients were certified only in mathematics or science, per programmatic requirements.

Table 4

Initial Certification Area by Noyce Participation, 2010–2018

	Noyce Recipients	Non-Noyce Recipients	Total
Core Subjects	0	22	22
Bilingual Education	0	9	9
English Language Arts	0	5	5
Fine Arts	0	13	13
Foreign Language	0	1	1
General Elementary	0	90	90
Health and Physical Education	0	60	60
Mathematics	107	350	457
Science	60	162	222
Social Studies	0	14	14
Special Education	0	39	39
Vocational Education	0	16	16
Total	167	781	948

First-Year Placement

Like all teachers completing a teacher preparation program, Noyce recipients are hired by school districts and placed in specific campuses for their first year of teaching. As a program requirement, Noyce recipients must teach for the first two years in a high-needs campus. The type and characteristics of campuses hiring both Noyce recipient and non-Noyce recipient first-year teachers in the dataset were analyzed. Table 5 shows the campus types by Noyce program participation.

Table 5

First-Year Teacher Campus Type by Noyce Participation, 2010–2018

	Noyce Recipients	Non-Noyce Recipients	Total
Middle Schools	22	461	483
High Schools	139	263	402
Mixed Grade Level Schools	6	57	63
Total	167	781	948

In Texas, schools are categorized as elementary schools if they serve students in kindergarten through fifth grade, middle schools if they serve students in sixth through eighth grade, and high schools if they serve students in ninth through 12th grade. The schools that serve a range of students spanning two or more of these categories (e.g., K-12 or 6-12) are categorized as mixed grade level schools. From the table, it is clear that the large majority of Noyce scholarship recipients go on to teach in high schools, which is in stark contrast to the teachers not receiving a Noyce scholarship, who primarily teach in middle schools.

Of interest to this study is teacher placement into the highest-need campuses. Though often an ambiguous definition, for the purposes of this study, “highest-need” is defined as a campus with a population of at least 75% low-income students. The outcome variable definition of highest-need campuses was chosen primarily because of the large proportion of low-income students served in the Texas public school system and the established relationship between teacher turnover and low-income student populations (Ingersoll, 2004; Simon & Johnson, 2015). Between 2010 and 2018, the Texas public school student population grew by more than half a million students, yet the student population remained 59% economically disadvantaged, Texas’ proxy term for low-income, indicating that a student qualifies for the federal free or reduced lunch program (Texas Education Agency, 2010; 2018). Given that the majority of students in Texas are low-income and 70% of campuses have a majority of low-income students (Texas Education Agency, 2018), using the traditional bar used by the Noyce program of 50% or more low-income students to signal a high-need school would not be a classification of relevance to the state. In their first year of teaching, 661 (70%) of the 948 teachers in the dataset were hired by campuses with at least 50% low-income students, and 353 (37%) of the 948 teachers in the dataset were hired by campuses with at least 75% low-income students. Setting the definition of highest need at 75% low-income students more appropriately accounts for the large population of low-income students in Texas.

Retention

For the purposes of this study, retention was defined specifically as retention after the first year of teaching because of the importance of the first year to multiple aspects of the teaching career (Ingersoll et al., 2014). Teacher attrition has been well documented by previous studies of state and national data to be highest after the first year of teaching (Boyd et al., 2008; Liu, 2007) and was recently documented as such for Texas teachers (Horn, Burnett, Lowrey & White, 2020). Further, the effects of teacher preparation programs are strongest early in the teaching career, and the study of the effects of such programming is best conducted in the first few years of a teacher's career (Kaplan & Owings, 2003). Thus, in an attempt to monitor the effects of a preparation program on retention, this research focuses on retention after the first year of teaching.

The specific outcome variable of interest in this research is the retention of teachers at highest-need schools. As previously stated, highest-need campuses are defined as those serving student populations of at least 75% low-income students. Table 5 displays the retention of all teachers in the dataset and the retention of teachers at highest-need campuses. It is important to note the definitions of "teacher retention" and "teacher retention at highest-need campuses." To determine teacher retention, teachers are counted as retained at a highest-need school if they are teaching in consecutive years, without regard for the specific classroom assignment, campus, or district. A teacher is counted as retained if they move from one district to another, but remain in the teaching role. When examining teacher retention at highest-need campuses, remaining in a teaching role at a highest-need campus is considered retention. For example, a teacher could move from a sixth-grade science classroom in one highest-need school to a seventh-grade science classroom in a different highest-need school and be counted as retained. But if the teacher moved from a highest-need campus to teach at a campus with less than 75% low-income students, the teacher would be included in teacher retention but would not be included in teacher retention at highest-need campuses.

Table 6

Teacher Retention in Non-Elementary School Campuses and Highest-Need Campuses

	Teacher Retention		Teacher Retention at Highest-Need Campuses	
	#	%	#	%
First Year	948	-	353	-
Second Year	803	85%	254	72%

Table 6 shows that of the 948 first-year teachers in the dataset, 85% remained teachers in their second year, and 72% of the 353 teachers who taught their first year at a highest-need school remained in a teaching role at a highest-need school in their second year. The retention rate of all teachers in the dataset was slightly lower than Texas' documented second-year retention rate. Statewide, middle and high school teachers in Texas have demonstrated an average 90% retention rate into the second year of teaching for the past decade (Performance Analysis for Colleges of Education, 2008–2018).

Methods

Logistic regression was selected as the method of analysis to determine the effect of participation in Noyce programming on binary independent variables recruitment and retention in highest-need campuses. Logistic regression models for both recruitment and retention take the standard form with *v* number of independent variables:

$$\ln[\text{odds}] = a + b_1X_1 + b_2X_2 + \ldots + b_vX_v,$$

where the log odds of the dependent variable (recruitment and retention, separately) is predicted by the independent variables (*X*). The coefficients (*b*) indicate the change in log odds as the independent variable changes (Meyers et al., 2016).

Independent variable selection was first guided by literature and tested in the sample to create the most parsimonious models. The literature shows that teacher placement and retention is influenced by school characteristics, student characteristics, and individual teacher characteristics (Boyd et al., 2006). In the dataset, the highest-need campus variable serves as a measure of low-income students. Individual teacher characteristics in the dataset are race and ethnicity, preparation pathway, and certification area. The school characteristic available in the dataset was grade type, meaning middle school, high school, or other grade level configuration (elementary schools were excluded from this analysis).

To determine the available variables most necessary in the model, Chi-square tests were used to identify the variables significantly related to both the placement and retention variables for highest-need schools. Teacher race and ethnicity surfaced as independent variables in the initial highest-need recruitment model, as chi-squared tests of independence established significant relationships between teachers who identified as African American (χ^2=34.18, ρ<0.01), Hispanic (χ^2=33.88, ρ<0.01), two or more races (χ^2=5.36, ρ<0.05), and white (χ^2=80.16, ρ<0.01) and placement at highest-need schools. It should be noted that the race and ethnicity variable was not included in any of the models for retention since a chi-squared test of independence showed no relationship between race and ethnicity and retention, likely influenced the restricted subset of teachers recruited to highest-need schools was composed of more minority teachers (18% African American, 32% Hispanic, 14% Asian, 35% white).

The certifying organization, or the institution where the teacher received their preparation and certification, was significantly related to the placement and retention at highest-need schools. This signals differences among institutions, including differences in Noyce programming, implementation, and other variation not captured in the dataset, thus variables for the four participating institutions were included in the model. Chi-squared tests of independence identified significant relationships between Urban R1-1 (χ^2=37.99, ρ<0.01), Urban Open-Access (χ^2=9.14, ρ<0.01), and Rural Doctoral (χ^2=48.17, ρ<0.01) and placement at highest-need schools. Chi-square tests established significant relationships between retention and Urban R1-1 (χ^2=25.2244, ρ<0.01), Urban R1-2 (χ^2=12.192, ρ<0.01), and Rural Doctoral (χ^2=10.489, ρ<0.01) certifying organizations.

Results

In order to examine the extent to which participation in Noyce programming influenced the recruitment and retention of STEM teachers at highest-need schools, this study employed logistic regression as the analytic tool. Logistic regression modeling was applied to the dataset of 948 first-year STEM teachers from four public institutions in Texas to evaluate the strength and appropriateness of each of three models for each outcome variable.

Recruitment

Table 7 displays the number and percentage of Noyce recipient teachers and non-Noyce recipient teachers hired and placed in highest-need schools. Of the 167 Noyce recipient teachers in the dataset, 34% were hired at a highest-need campus in their first year of teaching. In comparison, 38% of the 781 non-Noyce recipient teachers were hired at highest-need campuses in their first year of teaching.

Table 7

First-Year Teachers Placed in Highest-Need Schools, by Noyce Participation

	Noyce Recipients		Non-Noyce Recipients	
	#	%	#	%
Highest-Need Schools	56	34%	297	38%
Total	167		781	

To determine the model of best fit for recruitment at highest-need schools, three models were compared. Model 1 included only Noyce participation as a predictor variable; Model 2 included additional variables for teacher race and ethnicity; and Model 3 included additional variables for the different certifying organizations. The results for each are displayed in Table 8.

Table 8

Logistic Regression Analyses of Recruitment of Teachers at Highest-Need Campuses

Model 1 Predictor	β	$SE\ \beta$	Wald's χ^2	df	ρ	Odds Ratio
Noyce Participation	-0.196	0.180	1.189	1	0.276	0.822
Constant	-0.488	0.074	43.294	1	0.000	0.614
Log likelihood = -625.269 Hosmer and Lemeshow goodness of fit(0) =0 , ρ = - $\chi^2(1, N = 948) = 1.20$, ρ=0.273						

Model 2	β	$SE\ \beta$	Wald's χ^2	df	ρ	Odds Ratio
Noyce Participation	-0.241	0.190	1.740	1	0.204	0.786
African American	1.848	0.552	11.223	1	0.001	6.356
Asian	1.021	0.544	3.534	1	0.061	2.776
Hispanic	1.450	0.529	7.508	1	0.006	4.264
White	0.118	0.520	0.053	1	0.820	1.126
Constant	-1.214	0.509	5.664	1	0.017	0.297
Log likelihood = -575.893 Hosmer and Lemeshow goodness of fit(4) = 5.07, ρ= 0.2802 $\chi^2(5, N = 948) = 99.96$, ρ= 0.000						

Model 3	β	$SE\ \beta$	Wald's χ^2	df	ρ	Odds Ratio
Noyce Participation	0.053	0.221	0.058	1	0.809	1.055
African American	1.378	0.239	33.178	1	0.000	3.964
Hispanic	0.956	0.173	30.581	1	0.000	2.603
Urban R1-2	-0.560	0.192	8.526	1	0.004	0.571
Rural Doctoral	-1.247	0.200	38.813	1	0.000	0.287
High School	-0.549	0.161	11.628	1	0.001	0.578
Constant	-0.292	0.126	5.382	1	0.021	0.746
Log likelihood = -557.180 Hosmer and Lemeshow goodness of fit(24) = 28.62, ρ= 0.235 $\chi^2(6, N = 948) = 137.38$ $\rho = 0.000$						

As a baseline model, Model 1 included only Noyce participation as a predictor variable. Building on Model 1, Model 2 included the race and ethnicities shown to have a relationship with recruitment at highest-need schools with chi-square tests of independence. Model 3 built on Model 2 by incorporating the significant predictors of identifying as African American or Hispanic with certification by the Urban R1-2 and Rural Doctoral organizations shown to have a relationship with placement. Progressing from Model 1 to Model 3, the log likelihood increases, indicating a stronger model. Also, the chi-square test statistic resulting from the likelihood ratio test increases and is significant, indicating a model that can significantly predict the likelihood of teachers placed in highest-need schools with increasing precision. The Hosmer-Lemeshow goodness of fit test provides no evidence to reject the null of ill-fit for Model 3. Thus, we can confidently interpret the odds ratios of the predictor variables.

The likelihood of STEM teachers recruited at highest-need schools is significantly related to the race and ethnicity of the teacher, the certifying institution, and the grade levels served by the school. Teachers identifying as African American (odds ratio=3.964) were almost four times as likely and those identifying as Hispanic (odds ratio=2.603) were more than twice as likely to be recruited at the highest-need schools. Teachers placed in high schools were half as likely to teach at the schools of highest-need (odds ratio=0.578), and certification through two of the four public institutions—Urban R1-2 and Rural Doctoral—made teachers less likely to be placed in highest-need schools (odds ratios=0.571 and 0.287). Noyce participation had no significant influence on the likelihood of STEM teachers being placed in highest-need schools.

Retention

Like the model development for placement, three retention models were compared and employed to analyze the subset of 353 teachers who were placed in highest-need schools. Noyce recipient teachers had a 64% retention rate at highest-need schools, as 36 of the 56 first-year teachers were retained into their second year. In comparison, non-Noyce recipient teachers demonstrated a 73% retention rate at highest-need schools, as 218 of the 297 first-year teachers were retained into their second year. Model 1 included only Noyce participation as a predictor variable; Model 2 included additional variables for certifying organizations; and Model 3 included an additional variable for certification in mathematics or science. The analytic results for each are displayed in Table 9.

Table 9

Logistic Regression Analyses of Retention of Teachers at Highest-Need Campuses

Model 1 Predictor	β	$SE\ \beta$	Wald's χ^2	df	ρ	Odds Ratio
Noyce Participation	-0.427	0.201	1.932	1	0.166	0.652
Constant	1.015	0.362	59.753	1	0.000	2.760

Log likelihood = -208.531
Hosmer and Lemeshow goodness of fit(0) = 0.00, ρ = -
$\chi^2(1, N = 353) = 1.87$, ρ= .172

Model 2	β	$SE\ \beta$	Wald's χ^2	df	ρ	Odds Ratio
Noyce Participation	-0.036	0.353	0.010	1	0.921	0.965
Urban R1-1	0.603	0.792	1.932	1	0.165	1.827
Urban R1-2	-0.696	0.246	1.988	1	0.158	0.499
Rural Doctoral	-0.849	0.214	2.890	1	0.090	0.428
Constant	0.896	0.971	5.108	1	0.024	2.450

Log likelihood = -195.340
Hosmer and Lemeshow goodness of fit(3) = 7.75, ρ= 0.052
$\chi^2(4, N = 353) = 28.25$, ρ= 0.000

Model 3	β	$SE\ \beta$	Wald's χ^2	df	ρ	Odds Ratio
Noyce Participation	0.051	0.389	0.020	1	0.890	1.052
Urban R1-1	0.944	1.211	4.000	1	0.045	2.570
Urban R1-2	-0.402	0.345	0.608	1	0.436	0.669
Rural Doctoral	-0.632	0.274	1.513	1	0.220	0.532
Mathematics or Science certified	-0.572	0.163	3.920	1	0.048	0.564
Constant	0.971	1.057	5.905	1	0.015	2.640

Log likelihood = -193.308
Hosmer and Lemeshow goodness of fit(8) = 28.40, ρ= 0.0004
$\chi^2(5, N = 353) = 32.31$, ρ= 0.000

In comparison to the placement models, the retention models were weaker in their ability to predict the likelihood of teacher retention at highest-need schools. Model 1 served as the baseline model with Noyce participation as the predictor of retention. Model 2 included the certifying organizations with significant chi-square tests of independence with Noyce participation, and though it was a model that could significantly predict the likelihood of retention ($\chi^2(4, N = 353) = 28.25$, $\rho = 0.000$), the model did show some evidence of ill-fit with a Hosmer and Lemeshow test significant at the 0.052 level. Model 3 incorporated a variable signifying teacher certification in the areas of mathematics or science, and as a Wald test indicated, it made a significant contribution to the model ($\chi^2 = 3.90$; $\rho = 0.048$). Though Model 3 was able to significantly predict the likelihood of retention at highest-need schools ($\chi^2(5, N = 353) = 32.31$, $\rho = 0.000$), it did show some evidence of ill-fit (Hosmer and Lemeshow goodness of fit(8) = 28.40, $\rho = 0.0004$). Because of the less-than-ideal fit of the model, we interpret the resulting predictor coefficients and odds ratios with caution.

From the dataset of STEM teachers placed in highest-need schools, the likelihood of retention at highest-need schools is significantly related to the preparation institution and the certification area of the teacher. All teachers certified by the Urban R1-1 institution (odds ratio=2.57) were more than twice as likely to be retained in the highest-need schools. Those teachers certified in mathematics or science were less likely to remain teachers at the schools of highest-need (odds ratio=0.564).

Importantly, the findings presented should be appropriately contextualized within the limitations and specific definitions of the study. This study was limited to the data provided by four institutions that agreed to participate in the study. Though this study considered the race and ethnicity of the teachers, it did not consider the race and ethnicity of the student populations served, which in Texas is strongly related to the percentage of low-income students served in the schools. Also, though previous scholarship highlights the importance of school characteristics with regard to teacher retention (Harris & Sass, 2011; Johnson et al., 2012; Kraft et al., 2016; Loeb et al., 2005), the current study data did not support analysis of such variables. The absence of this data may contribute to the differences in teacher recruitment and retention outcomes seen among certifying organizations. Additionally, time parameters of the data made available by participating institutions limited the number of years in which Noyce recipients could be analyzed for retention. Result interpretations for retention apply only to the retention of first-year teachers.

Discussion and Conclusion

This study uniquely contributes to the understanding of the placement and retention of STEM teachers in the highest-need schools—those serving at least 75% low-income students. Examining a dataset of Texas teachers prepared by four public institutions and teaching at least one STEM class between 2010 and 2018, this study found no significant effect on the likelihood of teachers being placed or retained in highest-need schools and receiving a Noyce scholarship or stipend. Previous literature published regarding Noyce recipients has focused primarily on the decisions of recipients to become teachers and the influence of Noyce participation on perceived preparedness, rather than on placement and retention at highest-need schools (Kirchhoff & Lawrenz, 2011; Liou et al., 2010; Morrell & Salomone, 2017; Ticknor et al., 2017).

This study provides a contemporary extension of previous literature investigating the influence of Noyce participation on teacher placement and retention specifically in the highest-need campuses. In 2018, 70% (6,104) of Texas public school campuses served a majority low-income student population and had a statewide teacher turnover rate of 16.65 (Texas Education

Agency, 2018). Using the current Noyce definition of a high-need school as one that has a high percentage of students from low-income families, a high percentage of educators teaching outside of their certification area, or high teacher turnover rates (National Science Foundation, 2017; U.S. Department of Education, 2015), virtually all Texas campuses would qualify as high need. Thus, the definition of highest-need (serving at least 75% low-income students) was employed in this research to focus on the 39% (3,438) of campuses most in need of STEM teachers.

When the placement and retention of STEM teachers at highest-need schools were examined, researchers found that Noyce recipients were placed into highest-need schools at a modestly lower rate than their non-Noyce recipient peers (34% to 38%) and were retained at those schools at a lower rate than their non-Noyce peers (64% to 73%). After controlling for confounding variables, the logistic regression models confirmed that Noyce recipients were no more likely to be placed or retained at highest-need schools than their non-Noyce peers. The lack of relationship between Noyce participation and highest-need campuses found in this research suggests that in order to recruit and retain STEM teachers to the schools of highest-need, the Noyce program should consider redefining the characteristics that would qualify schools as those meeting criteria for teaching commitments. Said differently, while researchers are in agreement with the value that Noyce brings to expanding the pipeline of highly qualified STEM teachers, more work could be done to ensure that those teachers are going to and staying in classrooms with the highest needs.

Though Noyce participation had no effect on placement or retention at highest-need schools, the certifying organizations had relationships with placement and retention in interesting ways. Literature has established that preparation pathways influence teacher mobility (Boyd et al., 2006) through preservice teaching experiences (Ingersoll et al., 2012; Whipp & Geronime, 2017) and the preparation of teachers to serve diverse student populations (Clotfelter et al., 2007; Freedman & Appleman, 2009; Ronfeldt & Reininger, 2012). STEM teacher preparation is especially impacted by preparation, as effective STEM teachers require specific combination of deep content (Lee & Houseal, 2003; Menon & Sadler, 2016; Nadelson et al., 2013) and pedagogy (Eckman et al., 2016; President's Council of Advisors on Science and Technology, 2010) knowledge to succeed in today's high-stakes testing environment (Súarez & Wright, 2019).

In this study, preparation by three of the institutions (Urban R1-2, Urban Open Access, and Rural Doctoral) was negatively associated with STEM teachers' placement in highest-need campuses and had no effect on retention. Preparation by the Urban R1-1 institution was positively related to retention into the second year, though it had no relationship to placement. The varying influences of the institutions on placement and retention raise questions about generalizing the findings of earlier research to all university-based preparation institutions. The inconsistent influence on placement could signal informal or formal teacher pipelines from certain institutions to certain school districts or could be influenced by the schools surrounding the institutions. Further, the influence of only one of the certifying institutions on retention could indicate strong induction support. Future research into the influence of specific programs on placement and retention is needed.

An additional area of future exploration is the influence of race and ethnicity congruence among teachers and students in teacher placement and retention. Prior research shows that minority teachers are likely to stay in high-need schools (Podolsky et al., 2019) and minority students benefit from having a teacher of their own race and ethnicity (Clotfelter et al., 2007;

Egalite et al., 2015). In light of available literature identifying the benefits of Noyce financial support (Evans et al., 2019; Scott et al., 2006; Ticknor et al., 2017), such targeted efforts may also induce additional financial benefits—namely aiding in the reduction of college affordability-related disparities experienced by students of color in the teacher pipeline. Continued work exploring the myriad positive impacts of Noyce remain important.

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