Science Teacher Preparation

A Comparison of Noyce and Non-Noyce Scholarship Participation

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Abstract

Although studies have been published that examine the effectiveness of large federal scholarship programs for recruiting new science teachers, few studies have examined whether new teachers recruited by these programs are as well prepared as those who were not recruited and supported by these scholarships. In an effort to address the discrepancy in preparation, we analyzed data from three previous National Science Foundation Robert Noyce Teacher Scholarship Program grants and examined the relationship between Noyce support for science preservice teachers (PSTs) and three demographic characteristics, (a) gender, (b) race (those underrepresented in science, technology, engineering, and mathematics [URiS]), and (c) socioeconomic status (Pell eligibility), as measured by a high-stakes teacher performance assessment, the Performance Assessment for California Teachers (PACT). We found that science PSTs who receive Noyce support are better prepared to support their own students in academic language than those who do not

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receive Noyce support. We also found that, although there were no relationships between demographic characteristics and PST PACT scores, some differences existed between Noyce and non-Noyce PSTs *within* demographic categories, suggesting that Noyce PSTs are more prepared in the domain of academic language (if they are male or URiS) and in the domains of assessment and overall PACT average (if they are Pell eligible).

Introduction

A workforce well prepared in science, technology, engineering, and mathematics (STEM) is widely considered to be necessary both for individual success and for the competitiveness and prosperity of our nation (Langdon et al., 2011; National Academy of Sciences et al., 2010; National Science Board [NSB], 2015). However, the United States is failing to meet the current need for a STEM-capable workforce, at least in part because of a dearth of well-prepared K–12 STEM teachers (NSB, 2015). Our nation is suffering from teacher shortages primarily in math and science secondary school classrooms (American Association of Colleges for Teacher Education [AACTE], 2013; Center for Public Education, 2016), disproportionately impacting low-income students of color in high-need schools (Carver-Thomas & Darling-Hammond, 2017; NSB, 2018; Office of Planning, Evaluation, and Policy Development [OPEPD], 2016). Fewer people are entering the teaching field, as evidenced by the decline of enrollment in teaching certification programs nationwide by 35% between 2010 and 2015 (Carver-Thomas & Darling-Hammond, 2017). Causes for the STEM teacher shortage are complex and many, including the shortage of STEM majors who choose teaching as a career and characteristics specific to the teaching profession, such as comparatively low salaries and difficult working conditions (OPEPD, 2016; Podolsky et al., 2016).

Research on teaching effectiveness has evolved over several decades, beginning with personality traits of the teacher, then moving from a focus on teaching methods, the relationship between student learning and teacher behaviors, mastering competencies, and professional decision-making to a more recent emphasis on content-specific pedagogical knowledge and skills (Lederman & Lederman, 2015). Pedagogical content knowledge (Shulman, 1987)—the pedagogies associated with effectively teaching a specific content area—has thus become a focus in science teacher education.

Numerous state and federal initiatives have prioritized STEM education in an effort to increase the number of individuals who become K–12 math and science teachers. These programs encourage institutions of higher education to improve both teacher recruitment and teacher preparation.[1] One such initiative funded by the National Science Foundation (NSF) is the Robert Noyce Teacher Scholarship Program, first authorized by an act of Congress in 2002, reauthorized in 2007 and 2010, and amended in 2015. The Noyce scholarship program addresses K–12 STEM teacher shortages by providing funding for scholarships and programmatic support to attract and prepare STEM majors and STEM professionals to earn K–12 teacher certification. Future teachers who receive Noyce scholarships commit to completing 2 years of teaching in a high-need school district for each year of financial support (a *high-need district* is defined as serving at least one school with a high percentage of individuals from families with incomes below the poverty line, a high percentage of secondary school teachers not teaching in the content area in which they were trained to teach, or a high teacher turnover rate). In short, the mission of the program is to increase the number of K–12 teachers with strong STEM content knowledge who teach in high-need school districts. Support includes scholarships or stipends that range from at least $10,000 to more than $20,000 per year (up to the entire cost of attendance), along with activities that support professional development, such as mentoring and networking with other scholars and professionals through conferences and workshops.

The American Association for the Advancement of Science (AAAS; 2012) published innovative recruitment and support strategies that had been implemented in Noyce projects. The strategies shared in the publication were garnered from presentations at national Noyce conferences over the previous 3 years (2009–2011). At the time of publication in 2012, NSF's Noyce portfolio contained more than 350 projects at almost 470 colleges and universities in 45 states. As of 2015, NSF had invested more than half a billion dollars through Noyce scholarship programs. The AAAS (2012) publication shared Noyce strategies related to recruitment, mentoring, learning resources (curriculum), alternative teacher certification pathways, and partnerships. The effectiveness of the Noyce scholarship program can be measured in various ways, including its effectiveness as a recruitment tool to increase the numbers of math and science teachers overall; its effectiveness in broadening participation of underrepresented students into teaching STEM disciplines through recruitment strategies; and its impact on teacher retention and persistence, especially in high-need districts. However, the impact of receiving a Noyce scholarship on teaching preparedness and effectiveness is perhaps the most important dimension, given that the teacher is the most important variable in student achievement (Goldhaber et al., 2018; Heck, 2009; Rivkin et al., 2005; Rockoff, 2004; Rowan et al., 2002).

Research on teacher scholarship programs like the Noyce program has suggested that the programs can effectively recruit and retain teachers in the profession and in high-need schools if the scholarship covers a large portion of the tuition and targets high-need fields like STEM and if the scholarship recipients are committed to teaching, with a strong academic background and preparation (Podolsky & Kini, 2016). Furthermore, Baum and O'Malley (2003) suggested that loan forgiveness and service scholarships may be especially effective for recruiting teachers from low-income and minority backgrounds. A recent publication on the effectiveness of the Noyce scholarship as a recruitment tool (Morrell & Salomone, 2017) found that Noyce Scholars reported to varying degrees that the scholarship did affect their entry into the teaching profession; another study (Ticknor et al., 2017) found that the Noyce scholarship positively influenced perceptions of becoming a STEM teacher. Since a goal for NSF is to broaden the participation of underrepresented groups in math and science teaching, it is important that there is also some evidence that the Noyce scholarship is effective at attracting underrepresented students and at encouraging new teachers to choose low-income schools for their first teaching jobs (Liou et al., 2010).

While studies have been published that examine the effectiveness of Noyce scholarship programs in recruiting STEM teachers, despite the long-standing support of the federal government for the Noyce program and other teacher recruitment scholarship programs, few studies have examined the teaching effectiveness of scholarship recipients. Are recruits with scholarships that were designed to attract them to STEM teaching better prepared—or even as well prepared—as those who do not come to teaching with scholarships designed to recruit them? The NSF established a Noyce program research track (Track 4) in 2015 to fund research examining STEM teacher retention, persistence, and effectiveness. Track 4–funded studies should soon begin producing publishable research that examines Noyce Scholars' preparedness to teach effectively, especially in high-need settings, compared with non-Noyce-supported peers, but currently, there is very little published research in this area.

One study on Noyce teacher effectiveness used a classroom observation protocol with new math and science teachers and found that Noyce graduates from the UTeach program scored higher than non-Noyce UTeach and non-UTeach graduates in each section of the protocol (Walkington et al., 2011; Walkington & Marder, 2014). The four sections of the observation protocol were classroom environment, lesson structure, implementation, and math or science content. Two additional studies used self-assessment to measure preparedness. Bowe et al. (2011) found that Noyce Scholars who pursued alternative pathways to teaching were similar in most ways to Noyce Scholars who were enrolled in traditional pathways, and both sets felt equally well prepared to teach in high-need settings (as measured by self-report). An additional study used Noyce Scholars' self-reported scores on a survey that assessed the effectiveness of their preparation to teach math or science; in this case, Noyce Scholars' self-reports were statistically higher than non–Noyce Scholars' self-reports on four survey questions. The four questions on which they were statistically higher covered (a) understanding their subject matter, (b) providing developmentally appropriate instruction, (c) effectively differentiating instruction, and (d) understanding and addressing barriers that can impede student learning (Eckman et al., 2016). It is important to note that Noyce Scholars experienced a different teacher preparation program than non–Noyce Scholars at the same institution; this is not necessarily the case at universities with Noyce programs and is also not the case at the university where the current study took place.

This study was conducted at a 4-year regional comprehensive university that enrolls a diverse student body of more than 30,000 students, 56% of whom are women. Ninety-one percent of the students are undergraduates, whereas the teacher preparation programs at this institution and elsewhere in the state almost exclusively enroll postbaccalaureate students only. The institution where this case study took place is a minority-serving institution, with almost 38% of the student body from underrepresented groups (31% Hispanic, 6% African American) and 26% White, non-Hispanic. It was designated as an Asian American/Native American/Pacific Islander–serving institution in 2011 and as a Hispanic-serving institution in 2013. More than half of enrolled students come from a low-income household and are eligible for a federal Pell Grant. This university is part of a statewide system that produces approximately half of its state's teachers and approximately 8% of the nation's math and science teachers (approximately 1,500 per year).

The teacher preparation program in which these individuals were enrolled had an explicit focus on social justice and critical multiculturalism (and, more recently, an antiracist and culturally responsive teaching focus). It is a full-time, two-semester, postbaccalaureate program that includes coursework in the foundations of education, pedagogies (general and specific teaching strategies for different populations, including students with special needs and those learning English), content-specific methods (e.g., science, mathematics, social sciences), and field experiences/student teaching in both semesters of the program. All student teachers are placed in the same middle school/junior high school or high school classrooms for both semesters, gradually taking on more teaching duties within a coteaching model. The program graduates approximately 120 "single-subject" candidates per year (those who will teach junior high or high school). Approximately 10%–20% of program completers also earn a bilingual authorization in either Spanish or Hmong, which supports them in learning how to effectively teach classes in these other languages to students who are learning English. An Educational Equity Program provides advising, resources, and other support to preservice teachers (PSTs) who are first generation, undocumented, and/or multilingual/multicultural. Approximately two-thirds of program PSTs are female; approximately half are White. Latinx make up the most prominent demographic group after White (20%–25%), followed by Asian (~10%), two or more races (~10%), and Black (~2%), with the rest Pacific Islander, Native American, or declined to state. The program has a more than 95% completion rate.

The teacher preparation program is identical in every way regardless of whether the students included in this study were supported by the Noyce scholarship. All courses are the same, as is the student teaching experience. Noyce and non-Noyce PSTs were not programmatically cohorted separately; they were randomly distributed across all required credential courses (except science methods) with individuals who are learning to teach other subject matter disciplines, including the arts and humanities, social sciences, health science, and physical education. The Noyce and non-Noyce PSTs took a three-unit science methods course together, which included future middle school/junior high school and high school science teachers from all four science subdisciplines: biology, chemistry, physics, and earth sciences.

Tuss and Wang (2017) conducted an internal program evaluation for this Noyce case study that used graduates' self-reports of their preparedness to successfully execute the responsibilities of classroom teachers in a STEM discipline. All program graduates (those with Noyce funding and those without funding) were invited 1 year after completion of teacher certification to complete the online survey. One of the findings suggests that a relatively high proportion of math and science teachers with Noyce funding felt less prepared to manage student behavior, deliver an effective mix of teaching strategies, and identify student interests compared to non-Noyce-funded teachers. The number of program graduates who completed the survey was very low. Because of this, and because the study results contradict other research showing that Noyce Scholars' self-reports of their own effectiveness are higher than the self-reports of non-Noyce–Scholars, we believed that additional, standardized measures of teacher preparedness should be used to examine potential differences between Noyce and non-Noyce science PSTs.

Many states have standardized the assessment of new teacher preparedness by requiring PSTs to pass competency exams aligned with state or national teaching standards prior to earning teacher certification. Over a decade ago, Senate Bill 2042 mandated a valid and reliable competency exam for all PSTs in California, requiring them to pass a teacher performance assessment (TPA) embedded in their credential program for licensure. One such TPA is the Performance Assessment for California Teachers (PACT), which was adopted by more than 30 universities and is assumed to be one indicator of teaching effectiveness that measures PSTs' application of pedagogical strategies (Pecheone & Chung, 2006). PACT includes five different domains for evaluating teaching competence (planning, instruction, assessment, reflection, academic language), which are described in more detail herein.

In addition to using a high-stakes validated performance assessment rather than self-reported measures to compare preparedness to teach, this study examines preparedness across subpopulations based on race/ethnicity, gender, and socioeconomic status (SES; as measured by eligibility for a federal Pell Grant). We chose to compare preparedness across these categories because of the persistent underrepresentation of non-White individuals in STEM degrees earned and in the STEM teaching force and underrepresentation of women in certain STEM degree programs and fields (National Center for Science and Engineering Statistics, 2019). We also chose to compare across these categories because the teacher preparation program being studied explicitly focuses on social justice and preparing teacher candidates to be agents of change, committed to equity and inclusion in culturally and linguistically diverse schools and communities. The study design was an effort to elucidate whether there are gaps in preparation or support that hinder individuals from some backgrounds more than individuals from other backgrounds.

Although the science teaching force is becoming more diverse, showing above-average gains in racial/ethnic diversity from 1987 to 2012 compared to other teaching disciplines, it is still almost 85% White (AACTE, 2019; Ingersoll

& Merrill, 2017). Seventy-nine percent of the PSTs from this study are White. In addition, racial/ethnic gaps exist in terms of students' persistence in STEM during college (Chen & Weko, 2009; Griffith, 2010; Riegle-Crumb et al., 2019) and in the selection of STEM majors by women (Hill et al., 2010). The NSF and other major national and state bodies have called for diversifying the STEM teaching force (National Center for Science and Engineering Statistics, 2019; OPEPD, 2016). Therefore, we were interested to understand whether gender, race, and SES were related to science PSTs' preparedness to teach as measured by the PACT, both to add literature to the field regarding diversifying the STEM teaching force and because the teacher preparation program explicitly values and teaches antiracist pedagogies. To explore these issues, we used 7 years of PACT data from science PSTs to answer the following research questions:

1. To what extent are science PSTs who received Noyce support prepared for teaching (as measured by PACT) compared to those who did not receive Noyce support?

2. To what extent do individual demographic characteristics, such as gender, race/ethnicity, and SES, relate to PSTs' preparedness (as measured by PACT)? What, if any, differences exist between these demographic groups?

3. To what extent do individual demographic characteristics (gender, race/ethnicity, and SES) and Noyce participation relate to PSTs' preparedness (as measured by PACT)?

Methods

Study Population

A total of 93 science PSTs were included in this study. Twenty-two were Noyce scholarship recipients who were science majors pursuing junior high/high school science teacher certification after completing a science degree, through a postbaccalaureate teaching credential program. This group began the postbaccalaureate teaching credential program between 2009 and 2015 and earned their teaching credential between 2010 and 2016 (most students complete the postbaccalaureate program in two semesters). An additional 71 were science PSTs who completed the same postbaccalaureate teaching credential at the same institution between 2010 and 2016 but did not participate in the Noyce program. This second group is used as a comparison group for the Noyce PSTs. PACT data as well as gender, race/ethnicity, and Pell eligibility data were available for all individuals included in the study.

Outcome Measure: Performance Assessment of California Teachers

PACT is a high-stakes TPA that measures PSTs' application of subject-specific pedagogical knowledge in K–12 classrooms. The PACT for future elementary teachers is different from that for future secondary teachers. There are also different versions of PACT for future secondary teachers specific to different subject matter areas, because, for example, the effective application of pedagogical content knowledge in science is different from that in mathematics, English, or social studies, for example, the PACT in mathematics asks the PSTs to explain how they engaged students in procedural and computational thinking, whereas the PACT in science asks PSTs how they engaged students in inquiry. All versions of PACT include five tasks that must be completed. PSTs must first gather information on the school, community, and class where they are student teaching. They must also describe their students' strengths and needs in terms of their academic and language development in the content. This is called the "Context Task" and is not evaluated as its own domain but, as its name implies, is used to provide context for the evaluator (and presumably for the PST as well). PSTs also develop a series of lessons in their content area (planning task), videotape themselves teaching a learning segment (instruction task), collect evidence and analyze student learning (assessment task), and reflect upon theory and their own teaching practice in terms of student learning (reflection task). PSTs' competence in addressing academic language is also measured and is woven throughout all of the tasks such that PSTs must provide evidence of academic language support as they contextualize their teaching environment, plan, instruct, assess, and reflect. Again, the only difference among PACT's multiple versions and rubrics for future secondary teachers is an emphasis on subject-specific pedagogy across different subject matter content in the single-subject credential.

The PACT utilizes 12 rubrics across five domains for evaluation; four of the domains map directly onto tasks that were described earlier (the planning, instruction, assessment, and reflection tasks). The fifth domain is academic language (see Table 1). Each rubric describes the PST's performance along four levels from Level 1, which is the only failing score (the PST has not met the teaching standard), to Level 4 (the PST has met advanced levels of teaching standards). An overall score is computed to reflect the average level of performance ratings for the underlying rubric scores. The five teaching domains of the PACT scoring framework, the five tasks, and the corresponding rubrics for each domain are outlined in Table 1.

To pass PACT, PSTs must earn a score of at least 22 (a 2 or above in 10 of the rubrics and a 1 in the other two rubrics; there is no score of 0). The two allowable failing scores of 1 cannot be in the same task or domain. This means that a PST can pass the entire PACT but still have one or two failing scores (out of 12), as long as they are not in the same task or domain.

For the purpose of assessing the impact of Noyce participation on PST preparedness to teach, we used the first set of PACT scores attained by each PST (Noyce or non-Noyce). In other words, if a PST failed in the first attempt and had to take the PACT a second time, only the rubric score in the first but failed attempt was used in this analysis. For the purpose of the analysis, we looked at PSTs' overall PACT scores and subscores for each of the five domains, calculated as an average score of the items within that domain.

PACT evaluator training is standardized to increase validity and reliability across all programs and universities using PACT (Pecheone & Chung, 2006). A criterion for evaluator calibration is that scores must result in the same pass/fail decision. Evaluators must calibrate once per academic year with other content-specific evaluators.

Measures: Demographic Factors

In this study, we investigated the relationship of students' self-reported demographic characteristics with their preparation for teaching as measured by PACT. To do this, we included the following demographic variables in the analyses: (a) race/ethnicity (using federal designations)—underrepresented in STEM (URiS)—African American/Black, Hispanic, Native American, multiracial, Pacific Islander) and non-URiS (White, Asian); (b) SES as indicated by eligibility for a federal Pell Grant (not eligible for Pell and eligible for Pell); and (c) gender (female and male). The numbers of Noyce PSTs in the treatment group and non-Noyce PSTs in the comparison group, disaggregated by the demographic categories, are shown in Table 2. Although there are some differences—a larger proportion of female Noyce PSTs than non-Noyce PSTs, a larger proportion of URiS who had Noyce funding

Table 1
Scoring Framework for the Performance Assessment for California Teachers

Task	*Domain for evaluation*	*Rubrics*
Context[a]		
Planning	Planning	1. Establishing balanced instructional focus 2. Making content accessible 3. Designing assessments
Instruction	Instruction	4. Engaging students in learning 5. Monitoring learning during instruction
Assessment	Assessment	6. Analyzing student work 7. Using assessment to inform instruction 8. Using feedback to promote student learning
Reflection	Reflection	9. Monitoring student progress 10. Reflecting on learning
	Academic language[b]	11. Understanding language demands 12. Developing students' academic language

[A]Not evaluated as a teaching domain but is a required task.
[b]Not a stand-alone task but measured as a teaching domain.

than not, and more Pell-eligible students who had Noyce funding than not—these differences were not significant; thus there is no evidence of dependency between the Noyce indicator and the demographic indicators based on a chi-squared test, $p = .343$ for Noyce versus gender, $p = .157$ for Noyce versus race/ethnicity, $p = .420$ for Noyce versus Pell eligibility.

Analysis

Given that the Noyce PSTs were randomly distributed among the demographic subgroups, comparing the PACT scores in the Noyce group directly with those in the non-Noyce group should return an unbiased estimate of the differences between these two groups. The distribution of the overall PACT scores was found not to be normally distributed. To this end, we first performed a Mann–Whitney *U*-test (a nonparametric approach for independent samples) to address Research Question 1 for each domain and the overall PACT average. For Research Question 1, owing to the large difference in sample size, a subgroup of the non-Noyce sample was selected by matching demographic variables, specifically race/ethnicity (White, Asian, Hispanic, Native American, Pacific Islander, multiracial), science discipline taught (biology, physics, chemistry, geoscience), Pell eligibility, and gender (when

Table 2
Demographic Characteristics of Participants

	Noyce PSTs[a]		*Non-Noyce PSTs*[b]	
	n	*Percentage*	*n*	*Percentage*
Gender				
Female	14	64	37	52
Male	8	36	34	48
Race/ethnicity				
Non-URiS	15	68	56	79
URiS	7	32	12	17
Not reported	0	0	3	4
SES				
Non-Pell eligible	6	27	26	37
Pell eligible	16	73	45	63
Credential area				
Biology	14	64	46	65
Chemistry	1	5	5	7
General science	0	0	3	4
Geosciences	2	14	11	15
Physics	5	23	6	9

Note. PST = preservice teacher. SES = socioeconomic status. URiS = underrepresented in science, technology, engineering, and mathematics.
[a]n = 22. [b]n = 71.

possible; one was matched only on race/ethnicity and science discipline taught), to those of the smaller Noyce-funded sample to confirm findings from the larger comparison. We report on results of the Noyce group (n = 22) compared to the total non-Noyce group (n = 71) as well as the paired-sample non-Noyce group (n = 22). In addition to tests for significant differences between groups, we calculated effect sizes (Cohen's d for nonparametric tests) for each comparison to help interpret results with relatively small sample sizes. As a secondary analysis, a set of linear regressions was used to compare outcomes for Noyce and non-Noyce PSTs, controlling for all other demographic variables.

To address Research Question 2, we investigated the PACT scores using descriptive statistics to examine students' scores as they related to different demographic categories, including gender, race/ethnicity, and SES. Similar to Research Question 1, we used nonparametric Mann–Whitney U-tests of significance to look for differences and calculated effect sizes (Cohen's d) to report the magnitude of the differences across individual demographic groups. For Research Question 3, we looked across all comparisons and examined scores by demographics based on whether students were Noyce or non-Noyce. We used nonparametric Mann–Whitney U-tests of significance to examine differences and calculated effect sizes (Cohen's d) to report the magnitude of differences across individual demographic groups and within Noyce participation. Additionally, as secondary analyses for both Research Questions 2 and 3, we used linear regressions to examine the effects of demographic variables and interactions of demographic variables with Noyce and non-Noyce on PACT outcomes.

Results

Research Question 1

We found that overall, Noyce PSTs are slightly more prepared than their non-Noyce counterparts as measured by their PACT scores. The results of the Mann–Whitney U-test for comparing the Noyce group to the non-Noyce group are shown in Table 3, along with the results of comparing the Noyce group with a paired-sample non-Noyce group. The average scores for the entire PACT as well as for the five measured domains for each group are shown, in addition to the results of a test for significant differences and an effect size for each comparison.

The regression analysis controlling for all demographic variables revealed that the only significant effect, $p < .05$, of Noyce versus non-Noyce was for academic language. This was confirmed through the pairwise comparison analysis in which the only statistically significant difference in PACT scores was in the academic language domain, where Noyce PSTs scored higher than total non-Noyce PSTs (.44, small effect size) and paired-sample non-Noyce PSTs (.54, medium effect size). Cohen (1988) outlined a range of .2–.49 to be a small effect size and .5–.79 a medium effect size. Noyce PSTs also scored higher than total non-Noyce PSTs and the paired-sample non-Noyce group for every other PACT domain. All but one of these differences (for instruction compared with the total non-Noyce group), though not statistically significant, had small to medium effect sizes.

Research Question 2

Across all PACT domains, no statistically significant differences were revealed by the linear regression or pairwise analysis across demographic characteristics of gender, race/ethnicity, or SES, so we report average PACT scores for the variables we have constructed within each demographic characteristic: male and female (gender), URiS and non-URiS (race/ethnicity), and Pell and non-Pell (SES). We also report effect sizes when comparing average PACT scores related to these variables (see Table 4).

Although females' PACT averages were slightly higher than males', the differences were not statistically significant, and there were small or nonexistent effect sizes, illustrating that the groups performed functionally as well on all the PACT domains. Similarly, for URiS/non-URiS, although there were some differences, none were statistically significant, and all had small or nonexistent effect sizes. Across all PACT domains, the differences between PSTs who were and were not Pell eligible were neither statistically significant nor had even a small effect size.

Table 3

Comparison of Noyce and Non-Noyce Preservice Teacher Performance Assessment for California Teachers Scores

	Noyce PSTs,[a] M (SD)	*Non-Noyce PSTs,[b] M (SD)*	*Mann–Whitney U-test for total non-Noyce*	*Paired-sample non-Noyce PSTs, M (SD)*	*Mann–Whitney U-test for paired-sample non-Noyce*
PACT domain					
Planning	2.79 (0.44)	2.63 (0.43)	$p > 0.05$; $d = 0.27$	2.62 (0.43)	$p > 0.05$; $d = 0.36$
Instruction	2.25 (0.55)	2.15 (0.52)	$p > 0.05$; $d = 0.15$	2.07 (0.46)	$p > 0.05$; $d = 0.34$
Assessment	2.42 (0.45)	2.27 (0.43)	$p > 0.05$; $d = 0.30$	2.29 (0.46)	$p > 0.05$; $d = 0.37$
Reflection	2.39 (0.55)	2.25 (0.45)	$p > 0.05$; $d = 0.21$	2.26 (0.41)	$p > 0.05$; $d = 0.23$
Academic language	2.32* (0.40)	2.10* (0.34)	$p < 0.05$; $d = 0.44$	2.07* (0.33)	$p < 0.05$; $d = 0.54$
Overall PACT average	2.46 (0.37)	2.31 (0.33)	$p > 0.05$; $d = 0.39$	2.29 (0.32)	$p > 0.05$; $d = 0.54$

Note. PACT = Performance Assessment for California Teachers. PST = preservice teacher.
[a]$n = 22$. [b]$n = 71$.
*$p < .05$.

Research Question 3

Table 5 reports PACT scores for each demographic variable and domain, in addition to the overall PACT average. We tested for significant differences within each demographic characteristic and report effect sizes between Noyce and non-Noyce participants.

When examining PACT scores in Table 5, only one significant difference was found: For Pell-eligible PSTs, those who participated in Noyce scored higher on the overall PACT average (with a medium effect size) than PSTs who did not participate in Noyce. Three additional comparisons yielded medium effect sizes where Noyce participants scored higher than non-Noyce participants: (a) In the assessment domain, Pell-eligible PSTs scored higher than Pell-eligible PSTs who were non-Noyce; (b) in the academic language domain, males with Noyce support scored higher than males who were non-Noyce; and (c) also in the academic language domain, URiS with Noyce support scored higher than URiS without Noyce. Linear regressions examining interactions between Noyce and demographics revealed a significant interaction of Pell and Noyce on PACT average scores but no other effects on PACT outcomes.

Discussion and Implications for Science Teacher Education

Our analysis yielded three findings using science PSTs' PACT scores as a measure of their teaching preparedness: (a) Noyce PSTs scored significantly higher in the academic language domain of PACT than non-Noyce PSTs; (b) there were no significant relationships between demographic characteristics of gender, race/

Table 4

Comparison of Performance Assessment for California Teachers Scores by Demographic

	PACT domain					
	Planning	Instruction	Assessment	Reflection	Academic language	Overall PACT average
Gender						
Female,[a] M (SD)	2.71 (0.41)	2.18 (0.50)	2.35 (0.41)	2.33 (0.53)	2.21 (0.36)	2.4 (0.33)
Male,[b] M (SD)	2.61 (0.46)	2.17 (0.57)	2.25 (0.47)	2.21 (0.42)	2.08 (0.36)	2.3 (0.35)
Effect size	$d = 0.19$	$d = 0.03$	$d = 0.24$	$d = 0.17$	$d = 0.30$	$d = 0.24$
Race/ethnicity						
Non-URiS,[c] M (SD)	2.67 (0.46)	2.22 (0.56)	2.36 (0.45)	2.32 (0.51)	2.14 (0.35)	2.37 (0.36)
URiS,[d] M (SD)	2.65 (0.36)	2.03 (0.42)	2.14 (0.37)	2.18 (0.38)	2.24 (0.42)	2.27 (0.28)
Effect size	$d = 0.08$	$d = 0.19$	$d = 0.28$	$d = 0.41$	$d = 0.16$	$d = 0.25$
SES						
PELL,[e] M (SD)	2.68 (0.43)	2.16 (0.53)	2.29 (0.46)	2.28 (0.50)	2.15 (0.38)	2.34 (0.35)
Non-PELL,[f] M (SD)	2.66 (0.45)	2.19 (0.53)	2.33 (0.44)	2.28 (0.46)	2.15 (0.35)	2.35 (0.33)
Effect size	$d = 0.01$	$d = 0.03$	$d = 0.10$	$d = 0.01$	$d = 0.03$	$d = 0.01$

Note. N = 93. PACT = Performance Assessment for California Teachers. SES = socioeconomic status. URiS = underrepresented in science, technology, engneering, and mathematics.
[a]$n = 51$. [b]$n = 42$. [c]$n = 71$. [d]$n = 19$. [e]$n = 61$. [f]$n = 32$.

ethnicity, and SES and PSTs' PACT scores; and (c) some small differences (either statistically significant or with a medium effect size) existed between Noyce and non-Noyce PSTs within demographic categories, with Noyce PSTs scoring higher than non-Noyce PSTs in each case. Specifically, PSTs who participated in Noyce scored higher than non-Noyce PSTs if they were Pell eligible (on the assessment domain and the overall PACT average), if they were males (on the academic language domain), and if they were URiS (also on the academic language domain).

Our results indicate that PSTs with Noyce support are at least as well prepared as, and may be better prepared in some ways than, those without Noyce support. The Noyce scholarship program is designed as a recruitment tool to attract "undergraduate STEM majors and STEM professionals, especially those of the highest achievement and ability who might otherwise not have considered a career in K-12 teaching . . . to become teachers in high-need local educational agencies" (National Science Foundation [NSF], 2017, para. 1). Because recruitment is fo-

Table 5
Performance Assessment for California Teachers Scores by Demographic Characteristic and Noyce Participation

	Gender		*Race/ethnicity*		*SES*	
PACT domain	*Female*[a]	*Male*[b]	*Non-URiS*[c]	*URiS*[d]	*Pell*[e]	*Non-Pell*[f]
Planning						
Noyce, *M (SD)*	2.83 (0.47)	2.71 (0.42)	2.85 (0.47)	2.67 (0.39)	2.85 (0.38)	2.61 (0.57)
Non-Noyce, *M (SD)*	2.67 (0.38)	2.60 (0.47)	2.63 (0.45)	2.64 (0.36)	2.62 (0.43)	2.67 (0.43)
Effect size	$d = 0.35$	$d = 0.14$	$d = 0.36$	$d = 0.10$	$d = 0.45$	$d = 0.09$
Instruction						
Noyce, *M (SD)*	2.21 (0.58)	2.31 (0.53)	2.33 (0.56)	2.07 (0.54)	2.19 (0.57)	2.42 (0.49)
Non-Noyce, *M (SD)*	2.16 (0.47)	2.13 (0.58)	2.19 (0.56)	2.00 (0.37)	2.16 (0.52)	2.14 (0.54)
Effect size	$d = 0.06$	$d = 0.26$	$d = 0.21$	$d = 0.06$	$d = 0.04$	$d = 0.42$
Assessment						
Noyce, *M (SD)*	2.45 (0.46)	2.37 (0.45)	2.51 (0.45)	2.24 (0.42)	2.48 (0.44)	2.28 (0.49)
Non-Noyce, *M (SD)*	2.31 (0.38)	2.22 (0.48)	2.32 (0.44)	2.08 (0.35)	2.22 (0.45)	2.35 (0.38)
Effect size	$d = 0.29$	$d = 0.28$	$d = 0.35$	$d = 0.35$	$d = 0.50$	$d = 0.14$
Reflection						
Noyce, *M (SD)*	2.35 (0.56)	2.44 (0.56)	2.43 (0.64)	2.29 (0.39)	2.44 (0.60)	2.25 (0.42)
Non-Noyce, *M (SD)*	2.32 (0.52)	2.16 (0.36)	2.29 (0.48)	2.13 (0.38)	2.22 (0.45)	2.29 (0.47)
Effect size	$d = 0.05$	$d = 0.38$	$d = 0.17$	$d = 0.38$	$d = 0.30$	$d = 0.03$
Academic language						
Noyce, *M (SD)*	2.32 (0.37)	2.31 (0.46)	2.30 (0.37)	2.36 (0.48)	2.31 (0.40)	2.33 (0.41)
Non-Noyce, *M (SD)*	2.16 (0.35)	2.03 (0.32)	2.10 (0.34)	2.17 (0.39)	2.09 (0.36)	2.12 (0.33)
Effect size	$d = 0.03$	$d = 0.54$	$d = 0.36$	$d = 0.50$	$d = 0.47$	$d = 0.37$
Overall PACT average						
Noyce, *M (SD)*	2.47 (0.37)	2.45 (0.39)	2.52 (0.37)	2.34 (0.35)	2.50* (0.36)	2.39 (0.41)
Non-Noyce, *M (SD)*	2.35 (0.31)	2.26 (0.34)	2.33 (0.35)	2.23 (0.24)	2.29* (0.33)	2.34 (0.32)
Effect size	$d = 0.31$	$d = 0.45$	$d = 0.41$	$d = 0.40$	$d = 0.52$	$d = 0.16$

Note. Noyce, $n = 22$. Non-Noyce, $n = 71$. PACT = Performance Assessment for California Teachers. SES = socioeconomic status. URiS = underrepresented in science, technology, engineering, and mathematics.
[a]Noyce, $n = 14$; non-Noyce, $n = 37$. [b]Noyce, $n = 8$; non-Noyce, $n = 34$. [c]Noyce, $n = 15$; non-Noyce, $n = 56$.
[d]Noyce, $n = 7$; non-Noyce, $n = 12$. [e]Noyce, $n = 16$; non-Noyce, $n = 45$. [f]Noyce, $n = 6$; non-Noyce, $n = 26$.
* $p < .05$.

cused on those who may not have previously considered becoming K–12 teachers, to teach in the highest-need schools, it is particularly important to determine whether Noyce-supported teachers are as well prepared to teach as those who were not supported by the Noyce scholarship (who may have been planning all along to become K–12 science teachers).

We have identified a number of possible explanations for the significant differences and medium effect sizes in PACT scores, including (a) professional development opportunities that were in place for Noyce PSTs but unavailable for non-Noyce PSTs; (b) different types of undergraduate science content preparation between Noyce and non-Noyce PSTs; and (c) the Noyce scholarship filling a funding gap for low-income PSTs to finance their education, allowing them to focus their time on preparing to teach rather than on working.

One potential explanation for the significant differences found between Noyce and non-Noyce PSTs could be that the Noyce program included a professional development component, in addition to scholarship funding. Differences found in this study in the academic language domain could be due to multiple opportunities for Noyce PSTs to learn professional knowledge and skills related to scientific literacy and academic language. These opportunities proliferated during the time period of this study (owing to the adoption of new literacy and science standards) and were not available to non-Noyce PSTs. The Common Core State Standards (CCSS), which include standards for literacy in science and technical subjects in Grades 6–12, were adopted at the same time that this Noyce-funded program began. Furthermore, a common set of practices across Next Generation Science Standards (NGSS) and CCSS supports scientific literacy, such as engaging in argument from evidence. This explicit connection between CCSS and NGSS practices supports literacy development in science, emphasizing sense making and discourse. Because this was new, it necessitated professional development for teachers to provide strategies that support students' academic language development in science, and the Noyce PSTs benefited from this.

Following the adoption of NGSS, science professional development opportunities in our region that concentrated on literacy and science integration proliferated, focusing on developing students' academic language via multiple modalities (speaking, writing, and participating in classroom discourse). The California Science Teachers Association (CSTA; 2019) released several related articles and offered a variety of professional development workshops throughout the state between 2013 and 2018, including (a) Integrating the Common Core Literacy Skills in Science Classes, (b) Science Literacy: Writing, Reading and Oral Language in CCSS, and (c) Implementing the Common Core Literacy Standards in the High School Science Classroom.

Other statewide organizations, such as the California Subject Matter Project (2019), which supports teachers' implementation of NGSS and literacy strategies, provided similar resources for teachers. Additionally, the Sacramento Area Science Project (SASP; 2019), whose mission is to provide high-quality professional development to the region's science teachers, attended to literacy and science in its workshops. Several of its professional development providers collaborated on *Success in Science Through Dialogue, Reading, and Writing*, which included strategies for infusing dialogue and literacy skills throughout the science curriculum (Beauchamp et al., 2011). Strategies from this book were used in many of the SASP workshops, which were attended by Noyce PSTs.

Noyce PSTs were given the opportunity to become members of CSTA and also attend these local, regional, and statewide professional development workshops and conferences. Noyce scholars attended a total of 33 workshops provided by SASP between 2010 and 2017; some attended more than 1. Several of the Noyce Scholars also attended CSTA conferences. Noyce PSTs' participation in these professional development workshops could have contributed to their significantly higher scores in the academic language domain, suggesting that they were better prepared to support their students in academic language development than non-Noyce PSTs. Registration data confirm that these professional development workshops were used only by Noyce PSTs and not by non-Noyce PSTs.

Differences found between Noyce and non-Noyce PSTs' PACT scores are not due to a difference in the teacher preparation program coursework or student teaching experience because the postbaccalaureate teaching credential program they all experienced was identical. However, the undergraduate science content preparation of Noyce and non-Noyce PSTs—the type of degree with which they entered the postbaccalaureate certification program having already been earned—had some differences. NSF requires that Noyce scholarship recipients have a degree in a STEM field prior to entering the postbaccalaureate credential program. The earned degrees for Noyce PSTs included biology, chemistry, geology, and physics but also degrees such as environmental science, mechanical engineering, and oceanography. Noyce does not allow scholarships for students with non-STEM degrees, such as psychology or business, nor does Noyce allow scholarships for students with health-related degrees, such as nursing or allied health (NSF, n.d.). In California, science PSTs can demonstrate content knowledge either through having substantial coursework in the area to be taught (i.e., a science degree) or passing a standardized exam that assesses their science content knowledge (the science California Subject Exam for Teachers [CSET]). Consequently, although most non-Noyce science PSTs did have a science degree, a little over one-third of PSTs earning their science credential during the time of this study did not. They had nonscience majors, the most common of which were liberal studies (primarily taken by future elementary teachers) and psychology, with passing scores on the science CSET exam to demonstrate their science subject matter knowledge.

Developing pedagogical content knowledge (Shulman, 1987)—the pedagogies associated with effectively teaching a specific content area—is important in becoming an effective teacher. Multiple versions of PACT exist, aligned to content areas, to explicitly measure PSTs' pedagogical content knowledge as an indicator of their teaching preparedness. Although all the science PSTs took the same credential program courses over their two semesters in the postbaccalaureate certification program, their undergraduate preparation for knowledge of the science content varied. Perhaps PSTs without a science degree scored lower across the board on PACT because their undergraduate content preparation was not in the science discipline for which they were earning the credential. The Noyce PSTs may have scored higher on all domains of PACT because they all had science degrees and presumably stronger content knowledge, which could lead to stronger pedagogical content knowledge. More research is needed on teacher preparedness and effectiveness in terms of undergraduate content preparation, which goes beyond the scope of this study. Are there significant differences in science teaching preparedness (as measured by summative performance assessment) between those who have earned an undergraduate STEM degree and those who have not?

Another finding illustrates no relationships between PSTs' PACT scores and demographic characteristics of gender, race/ethnicity, and SES (as indicated by Pell Grant eligibility). However, findings indicate differences in PACT scores between Noyce and non-Noyce PSTs within demographic categories, with Noyce PSTs scoring higher than non-Noyce PSTs. In fact, these differences are found in all three demographic categories: gender (male Noyce scored higher than male non-Noyce), race/ethnicity (UriS Noyce scored higher than URiS non-Noyce), and SES (Pell-eligible Noyce scored higher than Pell-eligible non-Noyce). A closer inspection of these participants reveals that the demographic categories of gender and URiS could be interacting with Pell eligibility.

Within Noyce, seven males were Pell eligible and only one was not Pell eligible. Also, within Noyce, more than twice the number of URiS were Pell eligible (n = 16) compared to not Pell eligible (n = 6). Thus the differences in PACT scores seen for males and URiS may be explained by an interaction with their Pell eligibility. The sample in this study was too small to investigate this relationship with statistical analysis, so it remains an area for future study. Given this, and that the only statistically significant difference within demographic categories was for Pell-eligible PSTs (Noyce PSTs scoring higher than non-Noyce PSTs), we focus on SES and financial support as potential explanations for this finding.

We examined differences based on Pell eligibility (as an indicator of SES) because SES continues to be linked to students' academic achievement (Sirin, 2005; Thomson, 2018; White, 1982) and because almost two-thirds (66%) of the students who were part of this case study were eligible for a Pell Grant. Owing to inflation, federal grants like Pell do not provide the total amount of funds necessary for many low-income students to finance college (Horch, 2020). When the Pell Grant amount (currently just $6,345 for 2020–2021, which is only about 75% of the cost of tuition and fees) is added to other grants for which many low-income students are eligible, the total only meets about half of the total cost of attendance during the credential year. Therefore Pell-eligible students must also either find scholarships or take out student loans to fill the funding gap (National Center for Education Statistics, 2019). This leads some PSTs to reject student loans and work to supplement the cost of attending college so they do not have to borrow money and pay back loans.

One potential explanation for the significant difference we found favoring Pell-eligible Noyce PSTs could be that the financial assistance of the Noyce program had a positive impact on low-income students' performance on PACT. Pell-eligible PSTs who received the Noyce scholarship scored higher on the assessment domain (medium effect size) and the overall PACT average (significant difference) than non-Noyce PSTs who were also Pell eligible. So, while all the Pell-eligible PSTs had financial need, those without the Noyce scholarship would have had to take out student loans, be offered other scholarships, and/or work to fully fund their education. Alternatively, Pell-eligible PSTs who received the Noyce scholarship were fully funded for the entire cost of attendance, which covers all living expenses (books and supplies, food and housing, transportation, and personal expenses), in addition to tuition and fees.

Our credential program requires substantial time in local high schools. During the years of this study, PSTs were required to be at school sites 5 days a week, at least 16 weeks per semester, for two semesters. This totaled more than 700 hours of required field experience and student teaching. PSTs also attended university courses 4–5 days per week in the late afternoons and evenings, making it very difficult to hold external employment. The financial support of Noyce could have taken the place of a job (or jobs), allowing PSTs more time to focus on their professional preparation to teach.

At the time of data collection, we were using PACT as a formally recognized TPA that is viewed by teacher preparation accrediting bodies as a valid and reliable measure of teacher preparedness. More recently, there has been movement toward a new TPA, the edTPA, which is a nationwide teaching competency exam adapted from PACT (Sato, 2014; Stanford University, 2019). We now use the edTPA.

The study has several limitations. A small sample of Noyce PSTs led to a lack of power for statistical comparisons. Additionally, Noyce PSTs were not randomly selected, and all Noyce PSTs had degrees in a STEM discipline, which was not true for all the non-Noyce science PSTs in the study (although those without a STEM discipline had passed a state-recognized science content exam). Although we would have liked to control for variables like grade point average and method of demonstrating content knowledge (STEM degree vs. exam) to reduce the amount of potential error in the analysis, that information was not available; the study was based on the data that were available at the time. Last, it is important to note that there were a large number of PACT evaluators (n = 16), which may have led to variations in scores, although all were trained and calibrated.

More research is needed to determine the extent to which Noyce scholarships, and the professional development that accompanies the scholarships, aid in teacher preparation, retention, and teaching effectiveness. Another area for future research is how national support like Noyce can attract career changers into the science teaching profession. Noyce also supports math PSTs, so how does the scholarship program aid them as well? We hope that this article can serve to continue dialogue about Noyce PST teaching effectiveness and additional data sources needed for evaluation, particularly with the introduction of Noyce scholarship program Track 4, focused on research related to retention, persistence, and effectiveness of math and science teachers who receive scholarship support from the Noyce program.

Very few studies have been published that examine whether science teachers recruited by scholarship programs like Noyce are better prepared to teach than those who are not supported by these scholarships. This study contributes to the advancement of science teacher education by highlighting significant differences found for Noyce scholarship recipients in their preparedness to teach. Our findings have important implications for science teacher education. First, receiving the Noyce scholarship made a significant difference for these science PSTs. Financial support during the credential year can positively impact the preparedness of those seeking to become science teachers. Specifically, students who are eligible for the federal Pell Grant can benefit from these scholarships and additional financial support to supplement the federal or state grants that are also available to low-income students. Second, participating in external professional development opportunities through conferences and workshops during the credential year may have been linked to science PSTs' preparedness to teach, particularly in supporting students with the demands of teaching and assessing academic language. Supporting science PSTs to engage with the science teaching community at professional development events can influence their learning and preparedness to teach. Finally, postbaccalaureate science teacher certification programs should consider examining whether the science content knowledge of PSTs who do not have science degrees is perhaps interfering with preparedness to teach.

Note

[1] For example, 100kin10, http://100kin10.org/; Math for America, https://www.math-foramerica.org/; and the Association of Public and Land-Grant Universities' Science and Mathematics Teacher Imperative, http://www.aplu.org/

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