

RESEARCH REPORT

Pathways to Teacher STEM Certification in Texas: A Case for Addressing the Minoritized Teacher Shortage

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Abstract: *For the United States to remain globally competitive, policymakers, researchers, and administrators emphasize the need for a highly skilled and diverse STEM workforce. As such, the US education system must recruit high-quality, diverse, STEM-certified teachers to improve STEM learning outcomes and career pathways for all students, including historically underrepresented minority students. Increased recruitment and retention of minoritized STEM teachers through alternative certification pathways will dissipate the shortage of qualified STEM teachers. The purpose of this quantitative study was to examine trends in STEM teacher certification by race or ethnicity to address minoritized teacher shortages in Texas, the second largest education authority in the US. The study analyzed 67,629 teacher certification records from the Texas Education Agency's State Board for Educator Certification. Results revealed disparities in Race or Ethnicity among STEM teachers that could dispel the teacher shortage gap if parity were achieved among White, Hispanic, and Black STEM teachers.*

Keywords: *STEM teacher certification, alternative certification programs, teacher shortage, minoritized teacher shortage, teacher certification*

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Amid globalization challenges, declines in H1-B visa allocations, rapid increases in technological advances, and demographical shifts, the United States (US) faces severe shortages of qualified science, technology, engineering, and mathematics (STEM) workers (Carnevale et al., 2011; Vincent & Velkoff, 2010). National and state policymakers, researchers, and administrators emphasize the need for a highly skilled and diverse STEM workforce for the US to remain globally competitive and to meet increasing STEM knowledge and skills gaps (Cherrstrom et al., 2022). To meet US STEM workforce demands, and to improve STEM learning outcomes and career pathways for all students, particularly historically underrepresented minority students, the US K-12 education system must address its shortage of high quality, diverse, STEM-certified teachers (Mentzer et al., 2019).

Mainstream news consistently reports on the national teacher shortage (Castro et al., 2018; Cowan et al., 2016; Dee & Goldhaber, 2017; Sutchter et al., 2016, 2019; Wiggan et al., 2020). In 2018, U.S. public schools reached a record high enrollment of 50.7 million students (National Center for Education Statistics, 2018b), warranting 1.5 million new teachers (Wiggan et al., 2020). Since 1985, the number of teachers produced by teacher preparation programs has grown, while the students-to-teacher ratio in public schools has increased (Cowan et al., 2016). Consequently, the national teacher shortage has resulted from staffing challenges in critical subjects (e.g., STEM, special education, bilingual, English language learners), particularly at low-income or high-poverty, high-minority, rural, and urban schools (Cowan et al., 2016; Dee & Goldhaber, 2017; Sutchter et al., 2016, 2019).

Research has revealed a minority or urban teacher shortage represented by the longstanding gap between minority students' percentage concerning minority teachers (Ingersoll et al., 2019; Sutchter et al., 2019). On average, high-poverty and urban schools are "3 to 10 times more likely to have teachers who are uncertified, not fully prepared, or teaching outside their field of preparation than students in predominantly White and more affluent schools" (Castro et al., 2018, p. 2). While efforts to recruit minority teachers have been successful, minority teachers have higher attrition rates than teachers at affluent White schools due to poor working conditions (Ingersoll et al., 2019; Sutchter et al., 2016, 2019; Wiggan et al., 2020). Furthermore, recruiting and retaining minority teachers is vital for equitable access to quality STEM education for all students and to meet our nation's increasing demand for STEM knowledge and skills (Ingersoll et al., 2019). Ultimately, the low number of STEM professionals in secondary STEM classrooms impacts the quality of teaching and student learning as well as workforce development (Mentzer et al., 2019). A diverse, high-quality, STEM-certified teacher workforce will improve STEM learning outcomes and career pathways for underrepresented minority students (Mentzer et al., 2019).

Alternative STEM certification pathways offer a viable solution to close the gap of qualified teachers across the nation. Increased recruitment and retention of minority teachers through alternative STEM certification pathways will dissipate the shortage of qualified STEM

teachers. Although researchers have indicated traditional pathways produce higher student outcomes (Anderson, 2006; Marder et al., 2020; Ruiz de Castilla, 2018; Schmidt et al., 2020), most states have responded to teacher shortages in various subject areas with alternative certification programs (Humphrey et al., 2008; Mentzer et al., 2019). Such programs more effectively alleviate the shortage of qualified minority STEM teachers and improve STEM learning outcomes for all students (Chamberlin-Kim et al., 2019). Since higher percentages of underrepresented minorities pursue alternative pathways over traditional certification (National Center for Education Statistics, 2018a), we posit alternative certification programs provide the most viable pathway to address the minority teacher shortage.

The purpose of this study was to examine trends in STEM teacher certification by Race or Ethnicity and gender to address minority teacher shortages in Texas. Our research question guiding the study was: What can certification data tell us about the efficacy of different pathways toward preparing teachers for STEM certification? The insights to this question gained from the current study has implications for teachers, teacher preparation programs, schools and districts, and ultimately students and our nation. This article continues with a review of the literature on teacher certification in Texas, followed by methods used in the study, results of the study, and discussion of results with implications.

Teacher Certification in Texas

Texas offers three common pathways for initial teacher certification: traditional certification, alternative certification program (ACP), and post-baccalaureate (post-bac) certification (Texas Education Agency, 2020b). For subsequent certifications in STEM and other subject areas, teachers pursue an additional certification-by-examination (cert-by-exam) pathway (Texas Education Agency, 2020a).

In the US and Texas, traditional or standard certification (also referred to as *traditional undergraduate program*) is the most prevalent pathway to teacher certification (Texas Education Agency, 2020b). Along this pathway, teacher certification is intertwined with requirements for obtaining a bachelor's degree at a four-year college or university. Most states refer to the initial teacher certification as *traditional* or *standard* or certification in the literature. More states have also implemented pre-collegiate urban teaching academies (e.g., Fletcher Jr. & Ashford, 2016) as magnet high school programs to encourage high school students to pursue traditional teaching pathways.

While most public school teachers are the product of traditional four-year degree programs, alternative certification (ACP) is a second pathway accounting for a growing percentage of educators. The ACP is a byproduct of Ronald Reagan's National Commission on Excellence in Education report, *A Nation at Risk*, which identified serious deficits in teacher preparation programs. According to LoCascio et al. (2016), the purpose of ACPs is "to certify

candidates who have strong academic area content knowledge but have limited or no background in formal teacher preparation” (p. 105). The benefits of alternative certification include fewer course requirements and decreased program completion time for the prospective teacher. Required to hold a bachelor’s degree for program admission, students are promoted to field-based teaching experiences sooner than undergraduate students enrolled in a traditional certification program. Developed in response to teacher shortages in various subject areas, ACPs are now common in most states (Bowling & Ball, 2018; Humphrey et al., 2008; LoCascio et al., 2016).

The post-baccalaureate (post-bac) certification, a third pathway, is considered an advanced degree in obtaining a teaching certificate in most states. The definition of post-bac varies across state lines and among institutions of higher education. In the state of Texas, post-bac is defined as a certification pathway best suited for those seeking an advanced (master’s or doctorate) degree with certification (Texas Education Agency, 2020b). According to Ruiz de Castilla (2018), the post-bac pathway may not require completing an advanced degree while completing the certification requirements. The University of North Texas (UNT) College of Education (2020) outlines the post-bac certification program “for graduates who did not pursue education studies but want to become a teacher, principal, or superintendent. . . . Courses from each of these programs may be applied to the master’s degree” (para. 1). However, “courses taken for the post-baccalaureate program do not lead to a degree. Instead, completion of the program qualifies students to take the required state certification examinations.” While the terms *post-baccalaureate* and *alternative certification* are interchangeably used, a key differentiator is cost. Programs offering a certificate in conjunction with an advanced degree typically have higher cost and longer duration.

In Texas, teachers with a valid Texas classroom teaching certificate and a baccalaureate degree may obtain additional certifications through additional certification-by-exam (cert-by-exam) (Texas Education Agency, 2020a) also referred to as *endorsement by exam* (Hollo et al., 2019) and *additional exam* (Ruiz de Castilla, 2018). While advantageous for teachers desiring to expand expertise, cert-by-exam is not an option for initial certification, teachers who teach students with visual impairments, or non-classroom teaching purposes (e.g., superintendent, principal, school counselor). Cert-by-exam offers a common pathway for teachers to obtain multiple certifications. Other states have varying processes for teachers to obtain additional certification. An online search revealed the terms *additional certification by examination* or *cert-by-exam* unique to Texas. As one example, the California Commission on Teacher Credentialing defines the initial teacher certification as a *preliminary credential*, and the subsequent credential as a *clear credential* (State of California Commission on Teacher Credentialing, 2019).

Texas, the second-largest education authority in the US, offers traditional certification, ACP, and post-bac pathways for initial teacher certification and cert-by-exam pathway for subsequent certifications in STEM and other subject areas (Texas Education Agency, 2020a, 2020b). Since higher percentages of underrepresented minorities pursue alternative pathways over traditional certification pathways (National Center for Education Statistics, 2018a), we posit alternative certification programs provide the most viable pathway to address the minority teacher shortage. In the next section, we discuss the methods used to examine trends in STEM teacher certification by race or ethnicity, and gender to address minority teacher shortages in Texas.

Methods

Population

Based on teacher data for the 2018-2019 school year, this study's population consisted of 67,629 STEM teachers, representing 16.9% of the 399,670 educators teaching in Texas public schools. Within this statewide teacher population, 59.4% ($n=237,467$) were White, followed by 27.2% ($n=108,569$) Hispanic, and 10.4% ($n=41,470$) Black. The remaining 3.0% ($n=12,164$) consisted of the Other race or ethnicity category. Among White teachers, 19.0% ($n=45,148$) were STEM certified compared to Hispanic and Black teachers, respectively 13.0% ($n=14,088$) and 12.9% ($n=5,328$). The Other race or ethnicity group had the highest percentage of STEM teachers, 25.2% ($n=3,065$). By gender, there were four times more female teachers ($n=265,292$) than male teachers ($n=66,749$) 2018-2019. Similarly, there were two times more female STEM teachers ($n=45,001$) than male STEM teachers ($n=22,628$). However, among only 14.5% of female teachers, were STEM certified compared to 25.3% of male teachers

Data

This study's primary data came from the teacher certification records maintained by the State Board for Educator Certification (SBEC) at the Texas Education Agency (TEA). In 1995, the Texas Legislature created SBEC to oversee all aspects of the preparation, certification, and standards of conduct of public school educators (Texas Education Code, 2020). The data contained multiple records per teacher, where each record represented the teacher's certification to teach a subject (e.g., biology, physics, chemistry) within a broader field (e.g., science). In this study, a STEM certification included any subject in computer science, mathematics, or science, or the subjects of technology applications or technology education in the field of technology in vocational education programs.

Each certification was associated with a *standard* or *provisional* type. Standard certifications must be renewed every five years if issued on or after September 1, 1999, while provisional

certifications are for life if issued before September 1, 1999 (Texas Education Code, 2020). Both certification types had a start date and an expiration date for standard certifications. Moreover, all records had one of four certification pathways: (standard) traditional program, alternative certification program (ACP), post-baccalaureate (post-bac), or additional certification-by-examination (cert-by-exam). Teacher demographic data included race or ethnicity (White, Hispanic, Black, or Other) and gender (F or M).

Measures

The longitudinal nature of the data allowed us to build a certification profile for each teacher consisting of the initial and subsequent certifications in STEM fields. In so doing, we created numerical measures for the study as follows. Using the certification's start issuance date, for each teacher, we chronologically sorted records to identify the initial and subsequent certifications. We then kept the initial and the next encountered certification if in a STEM field. For each teacher, we calculated the number of years between a certification's start date and 2019, the referenced school year for data collection, and the number of years between the start dates of the initial and next encountered certification in a STEM field. We then compared these measures against our independent calculations from the raw data for teachers randomly selected so that, we could ensure our SAS code was reliable and valid in producing the measures for the current study. For analytical procedures, we relied on descriptive statistics to illuminate patterns and discoveries in the data in a meaningful way within the context of our research question.

Theoretical Framework

Since intersectionality (Crenshaw, 1991) is an appropriate theoretical framework to describe multifaceted racial and social identities of diverse individuals, we referenced its use in the context of education related to teacher professionals (Macias & Stephens, 2017). During this study, we utilized intersectionality theory to describe race and gender factors related the race or ethnicity, and gender status of diverse STEM teachers in the state of Texas.

Results

Race or Ethnicity of STEM Teachers

Table 1 shows the race or ethnicity, and gender distribution of STEM teachers in Texas. The results indicated a disparity in race or ethnicity among STEM teachers. This finding's relevance can be best realized relative to student demographics, as shown in the table. Of the 5,431,910 students in Texas public schools in the 2018-2019 school year (TEA, 2019), race or ethnicity distribution consisted of 27.4% (n=1,490,299) White, 52.6% (n=2,854,590) Hispanic, and 12.6% (n=685,775) Black students. In comparison, STEM teacher demographics for the 67,629 educators consisted of 66.8% (n=45,148) White, 20.8% (n=14,088) Hispanic, and 7.0% (n=5,328) Black teachers.

Table 1.
STEM Teachers in Texas: Race or Ethnicity, and Gender

Students (S)		STEM Teachers (T)		S:T Ratio	Parity	
Group	n	Percent	n	Percent	($S_n \div T_n$)	Required Shortage
Race or Ethnicity						
White	1,490,299	27.4	45,148	66.8	33.0	45,148 0
Hispanic	2,854,590	52.6	14,088	20.8	202.6	86,479 72,391
Black	685,775	12.6	5,328	7.9	128.7	20,775 15,447
Other	401,246	7.4	3,065	4.5	130.9	12,156 9,091
Total	5,431,910	100	67,629	100	80.3	164,557 96,928
Gender						
Female	2,647,524	48.7	45,001	66.5	58.8	45,001 0
Male	2,784,386	51.3	22,628	33.5	123.1	47,327 24,699
Total	5,431,910	100.0	67,629	100.0	80.3	92,328 24,699

The students-to-teacher ratio by race or ethnicity indicated 33.0 White students to every 1.0 White STEM teacher. In comparison, there were 202.6 Hispanic students for every Hispanic teacher and 128.7 Black students for every Black teacher. To achieve parity with White STEM teachers would require 86,479 Hispanic STEM teachers, 72,391 more than in the 2018-2019 school year. Similarly, parity with White STEM teachers would require 20,775 Black STEM teachers, 15,447 more than in the 2018-2019 school year. If parity were achieved among the three major race or ethnicity groups, the result would add 96,928 STEM teachers to the 67,629 in the 2018-2019 school year, for a total of 164,557 STEM teachers available to students in public schools.

Disparities also existed by STEM teacher gender. Of the 5,431,910 students in Texas public schools in the 2018-2019 school year (TEA, 2019), the gender demographics consisted of 48.7% ($n=2,647,524$) female and 51.3% ($n=2,784,386$) male. In comparison, STEM teacher demographics for the 67,629 educators consisted of 66.5% ($n=45,001$) female and 33.5% (22,628) male. The ratio of students-to-teacher by gender indicated 58.8 female students for every female STEM teacher. In comparison, there were 123.1 male students for every male STEM teacher. To achieve parity with female STEM teachers would require 47,327 male STEM teachers, 24,699 more than in the 2018-2019 school year, for a total of 92,328 STEM teachers available to students in public schools.

STEM Certified Teachers by Initial and Second Certification Field

Table 2 shows the distribution of STEM certified teachers by initial and next encountered certification in a STEM field and descriptive statistics for the number of years between a certification's start date and 2019. The data include two groups of teachers: teachers with initial

certification in a non-STEM field who later earned a certificate in a STEM field, and those with initial certification in a STEM field who went on to earn a second certificate in another STEM field. The 25,357 teachers with initial certification in non-STEM fields were certified, on average, 19.0 years ($SD=10.4$) before the 2018-2019 school year. For the first certification in a STEM field, 54.0% ($n=13,692$) of teachers did so in mathematics, followed by 27.7% ($n=7,018$) in science. The average years from their STEM certification to the 2018-2019 school year was 15.8 years ($SD=10.7$), which implies their STEM certifications were earned, on average, within four years after receiving their initial non-STEM certification.

In comparison, the 42,272 teachers with initial certification in STEM fields were certified on average, 13.4 years ($SD=9.7$) before the 2018-2019 school year. Of these STEM teachers, however, only 18.4% ($n=7,787$) went on to earn a second certification in another STEM field, primarily in the fields of science ($n=4,999$) followed by mathematics ($n=1,463$). For the second-STEM certified teachers, the average years from initial STEM certification and second STEM certification to the 2018-2019 school year were 18.1 years ($SD=10.8$) and 14.7 years ($SD=11.2$), respectively. Therefore, second-STEM certified teachers earned their second STEM certifications, on average, within four years after receiving their initial STEM certification.

Table 2.

STEM Certified Teachers in Texas: Initial and Second Certification Field

Years to 2018-2019 School Year							
Field	n	Percent	Mean	SD	Min	Median	Max
Teachers with Initial Certification in a non-STEM Field							
Bilingual Education	1,920	7.6	9.3	6.3	0	8	32
English Language Arts	2,304	9.1	21.3	9.5	1	22	54
Fine Arts	743	2.9	17.4	10.7	1	15	47
Foreign Language	205	0.8	17.8	11.1	1	15	47
General Elementary	11,590	45.7	19.7	9.8	0	20	54
Health & PE	3,962	15.6	20.0	11.0	1	18	57
Social Studies	1,261	5.0	21.4	11.3	1	21	55
Special Education	1,072	4.2	15.5	7.1	0	15	46
Vocational Education	2,300	9.1	20.4	11.3	1	19	58
Total	25,357	100	19.0	10.4	0	18	58
<i>First Certification in a STEM Field</i>							
Computer Science	649	2.6	17.4	8.5	1	18	44
Mathematics	13,692	54.0	18.0	11.0	0	18	57
Science	7,018	27.7	15.7	10.6	0	14	52
Technology	3,998	15.8	7.9	4.9	0	7	18

Total	25,357	100.0	15.8	10.7	0	14	57
<i>Teachers with Initial Certification in a STEM Field</i>							
Computer Science	635	1.5	20.5	9.4	1	20	45
Mathematics	21,164	50.1	12.3	8.4	0	11	58
Science	19,113	45.2	14.8	10.7	0	13	60
Technology	1,360	3.2	6.6	4.6	0	5	17
Total	42,272	100.0	13.4	9.7	0	12	60
<i>Second Certification in a STEM Field</i>							
Computer Science	509	1.2	9.5	8.9	1	5	34
Mathematics	1,463	3.5	16.4	12.1	0	13	57
Science	4,999	11.8	16.0	11.2	0	13	60
Technology	816	1.9	6.9	4.6	0	6	18
Total	7,787	18.4	14.7	11.2	0	12	60
(Initial Certification)			18.1	10.8	0	16	60
<i>No Second Certification</i>	34,485	81.6	12.3	9.1	0	11	58

STEM Certified Teachers' Initial and Second Certification Pathway by Race or Ethnicity

Table 3 shows the distribution of STEM teachers' initial and second certification pathways by race or ethnicity. While 54.1% (n=36,567) of STEM teachers earned their initial certification through a Traditional program, this was not always the case by race or ethnicity. Among White and Hispanic STEM teachers, 59.4% (n=26,824) and 49.3% (n=6,947) respectively completed a Traditional program to earn the initial certification. In comparison, 55.6% (n=2,961) of Black STEM teachers completed an Alternative Certification Program (ACP) to earn their initial certification.

Table 3.

STEM Certified Teachers in Texas: Initial and Second Certification Pathway by Race or Ethnicity

Race or Ethnicity					
Certification Pathways	White	Hispanic	Black	Other	Total
Initial Certification					
Traditional	26,824	6,947	1,662	1,134	36,567
	59.4	49.3	31.2	37.0	54.1
	73.4	19.0	4.6	3.1	100
ACP	13,782	6,050	2,961	1,513	24,306
	30.5	42.9	55.6	49.4	35.9
	56.7	24.9	12.2	6.2	100.0
Post-Bac	4,542	1,091	705	418	6,756
	10.1	7.7	13.2	13.6	10.0

	67.2	16.2	10.4	6.2	100.0
Second Certification					
Traditional	9,634	1,574	525	277	12,010
	21.3	11.2	9.9	9.0	17.8
	80.2	13.1	4.4	2.3	100.0
ACP	1,495	449	183	139	2,266
	3.3	3.2	3.4	4.5	3.4
	66.0	19.8	8.1	6.1	100.0
Cert-by-Exam	13,343	3,206	958	794	18,301
	29.6	22.8	18.0	25.9	27.1
	72.9	17.5	5.2	4.3	100.0
Post-Bac	424	63	62	18	567
	0.9	0.5	1.2	0.6	0.8
	74.8	11.1	10.9	3.2	100.0
Total Second Certification	24,896	5,292	1,728	1,228	33,144
	55.1	37.6	32.4	40.1	49.0
	75.1	16.0	5.2	3.7	100
No Second Certification	20,252	8,796	3,600	1,837	34,485
	44.9	62.4	67.6	59.9	51.0
	58.7	25.5	10.4	5.3	100.0
Total	45,148	14,088	5,328	3,065	67,629
	100.0	100.0	100.0	100.0	100.0
	66.8	20.8	7.9	4.5	100.0

Note. Entries: n, column%, row%.

Among the 67,629 STEM teachers, slightly less than 50% (n=33,144) completed a second certification in a STEM field. Of the four certification pathways to the second certification, the Cert-by-Exam was most prevalent for each race or ethnicity group. The least prevalent pathway was post-bac, with only 567 teachers consisting of about 75% (n=424) White, followed by 11.1% (n=63) Hispanic, and 10.9% (n=62) Black.

Of the remaining 34,485 STEM teachers not earning a second certification in another STEM field, Whites represented 58.7% (n=20,252), followed by Hispanics and Blacks with 25.5% (n=8,796) and 10.4% (n=3,600), respectively. However, the data paints a different picture when viewed by the race or ethnicity group. Among Blacks, 67.6% (n=3,600) did not earn a second certification in another STEM field, followed closely next by Hispanics with 62.4% (n=8,796). In

comparison, 44.9% (n=20,252) of the White STEM teachers did not seek a second certification in another STEM field.

Initial and Second Certification Pathways for STEM Teachers

Table 4 shows the distribution of STEM teachers by initial and second certification pathways and descriptive statistics for the number of years between the start dates of the initial and next encountered certification in a STEM field, if applicable. The findings illustrated the varied pathway combinations from the initial to the second certification. The Cert-by-Exam was the most prevalent pathway to the second certification in another STEM field. This was true, regardless of whether the teachers' initial certification was in a non-STEM or STEM field.

Note the certification pathways where the initial and second certification were both post-bac. The average time interval from the initial to the second certification for teachers was zero years (SD=0). This implies the post-bac pathway provides teachers with the shortest time interval to prepare for initial certification and then add a second certification in a STEM field.

Table 4.

STEM Certified Teachers in Texas: Initial and Second Certification Pathways for Non-STEM and STEM Initial Certifications

Certification and Pathway		Distribution		Years to Second Certification				
Initial	Second	n	Percent	Mean	SD	Min	Median	Max
Teachers with Initial Certification in non-STEM field								
Traditional	Traditional	9,874	98.1	0.7	3.1	0	0.0	42
ACP		118	1.2	6.2	4.1	0	6.0	21
Post-Bac		73	0.7	3.3	3.7	0	2.0	15
Traditional	ACP	220	12.0	11.3	7.1	0	10.0	32
ACP		1,556	84.8	0.1	0.8	0	0.0	11
Post-Bac		59	3.2	4.2	3.0	0	4.0	11
Traditional	Cert-by-Exam	6,542	50.2	6.8	7.6	0	4.0	46
ACP		5,098	39.1	3.8	4.0	0	3.0	32
Post-Bac		1,385	10.6	4.6	4.9	0	3.0	23
Traditional	Post-Bac	19	4.4	0.8	3.2	0	0.0	14
Post-Bac		413	95.6	0.0	0.0	0	0.0	0
Teachers with Initial Certification in STEM Field								
Traditional	Traditional	1,846	94.9	1.0	3.2	0	0.0	40
ACP		54	2.8	5.4	3.5	0	5.0	15
Post-Bac		45	2.3	4.6	3.9	0	4.0	15

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Traditional	ACP	32	7.4	10.0	7.6	0	9.5	34
ACP		386	89.6	0.1	0.9	0	0.0	11
Post-Bac		13	3.0	3.2	2.0	1	4.0	7
Traditional	Cert-by-Exam	2,045	38.8	6.1	6.8	0	4.0	47
ACP		2,250	42.7	3.3	3.7	0	2.0	24
Post-Bac		981	18.6	4.1	4.6	0	2.0	24
Traditional	Post-Bac	1	0.7	2.0		2	2.0	2
Post-Bac		134	99.3	0.0	0.0	0	0.0	0
Traditional	(No Second	15,988	46.4					
ACP	Certification)	14,844	43.0					
Post-Bac		3,653	10.6					

Note. Empty cells denote not applicable

Second Certification Pathway for STEM Teachers

Table 5 shows the distributions for the second certification pathways and, for each pathway, descriptive statistics for the number of years between the start dates of the initial and next encountered certification in a STEM field, if applicable. The table separately presents the results for teachers with initial certifications in non-STEM and STEM fields, followed by combined STEM teachers regardless of when they first certified in a STEM field. As shown earlier, the Cert-by-Exam (n=18,301) was the most prevalent second certification pathway, however, these results clearly indicated Cert-by-Exam also had the most considerable time interval of, on average, 5.1 years (SD=6.1) between initial and second certification in a STEM field. The least taken pathway to the second certification was Post Bac (n=567) but with the shortest time interval of, on average, zero years (SD=0.8) between initial and a second certification in a STEM field. Again, this implies the post-bac provides teachers with the shortest time interval to prepare for initial certification and then add a second certification in a STEM field.

Table 5.

STEM Certified Teachers in Texas: Second Certification Pathway for Non-STEM and STEM Initial Certifications

Second Certification Pathway	Distribution		Years to Second Certification				
	n	Percent	Mean	SD	Min	Median	Max
Teachers with Initial Certification in the non-STEM field							
Traditional	10,065	39.7	0.8	3.1	0	0	42
ACP	1,835	7.2	1.6	4.5	0	0	32
Cert-by-Exam	13,025	51.4	5.4	6.3	0	3	46
Post-Bac	432	1.7	0.0	0.7	0	0	14
Total	25,357	100.0	3.2	5.6	0	0	46

Teachers with Initial Certification in STEM Field							
Traditional	1,945	4.6	1.2	3.3	0	0	40
ACP	431	1.0	0.9	3.4	0	0	34
Cert-by-Exam	5,276	12.5	4.5	5.4	0	3	47
Post-Bac	135	0.3	0.0	0.2	0	0	2
Total	7,787	18.4	3.4	5.1	0	1	47
No Second Certification	34,485	81.6	n/a	n/a	n/a	n/a	n/a
All Teachers Certified in a STEM Field, Initial and/or Second Certification							
Traditional	12,010	17.8	0.9	3.2	0	0	42
ACP	2,266	3.4	1.5	4.3	0	0	34
Cert-by-Exam	18,301	27.1	5.1	6.1	0	3	47
Post-Bac	567	0.8	0.0	0.6	0	0	14
Total	33,144	49.0	3.3	5.4	0	1	47
No Second Certification	34,485	51.0	n/a	n/a	n/a	n/a	n/a

Discussion

Texas is the second-largest education authority in the US, educating 5.4 million students, nearly 10% of all students in the US, and employing 67,629 STEM teachers, nearly 17% of the 399,670 educators teaching in Texas public schools. Therefore, understanding most viable certification pathways to address the minority STEM teacher shortage in Texas also informs the broader minority STEM teacher shortage in the US (Schmidt et al., 2020).

Research has revealed a minority teacher shortage represented by the longstanding gap between the percentage of minority students in relation to minority teachers (Ingersoll et al., 2019; Sutter et al., 2019). Based on this study's results, we believe Texas could dispel the minority teacher shortage gap if parity were achieved among the three major race or ethnicity groups: White, Black, and Hispanic. To achieve a comparable to the 33.0 students-to-teacher ratios for Hispanics, Texas would require 86,479 Hispanic STEM teachers to achieve parity with White STEM teachers in Texas. Similarly, Texas would need an additional 20,775 Black STEM teachers to achieve parity of Black STEM teachers in Texas. In total, Texas would need to add 96,928 STEM teachers to the current baseline of 67,629 to achieve parity among the three major ethnic groups in the 2018-2019 school year.

In the US and Texas, traditional or standard certification (also referred to as *traditional undergraduate program*) is the most prevalent pathway to teacher certification (Texas Education Agency, 2020b). Likewise, this study found 54.1% (n=36,567) of all STEM teachers in Texas earned initial certification through a Traditional program. By Race or Ethnicity, we discovered fewer Hispanic STEM teachers 49.3% (n=6,947) than White STEM teachers 59.4% (n=26,824) earned their initial certification through a traditional pathway. This is important with regards to teacher

quality in the classroom. Studies situated in Texas illuminate traditional certification pathway and results. Schmidt et al. (2020) conducted a randomized survey with 2,134 newly certified teachers from traditional and ACPs and concluded teachers who receive traditional certifications have higher content preparation than alternatively certified teachers. However, certified teachers reported higher mathematics scores on college entrance examinations in grades 4-8. Anderson (2020) used a sample data set of 2,599 novice teachers (i.e., five years or less experience) matched to student achievement and found students perform better on high school math assessments when taught by a traditionally certified teacher. Marder et al. (2020) utilized multilevel models to examine student test score changes from the 2010-2011 to 2017-2018 school years, nested within classrooms, teachers, and school campuses. They found students enrolled in Algebra I classes taught by experienced teachers certified through traditional pathways achieved .03 to .05 gains (in standard deviation units) compared to students taught by alternatively certified teachers.

However, the study also found that 55.6% (n=2,961) of Black STEM teachers completed an ACP to earn their initial certification. Furthermore, more Blacks (67.6%, n=3,600) and Hispanics (62.4%, n=8,796) did not earn a second certification in another STEM field in comparison to 44.9% (n=20,252) of White STEM teachers. Therefore, findings support the notion that higher percentages of Black (13% vs. 5%), Hispanic (15% vs. 8%) and Multi-Race (32% vs. 22%) teachers pursue alternative pathways over traditional pathways (National Center for Education Statistics, 2018a).

This finding was not so surprising. Research has shown that many minority teachers who participate in ACP programs also grew up in large population urban areas compared to their White peers (Zeichner & Schulte, 2001). The benefits of alternative certification include fewer course requirements and decreased program completion time for the prospective teacher. Required to hold a bachelor's degree for program admission, ACP participating teachers are promoted to field-based teaching experiences sooner than undergraduate students enrolled in a traditional certification program.

When viewed from a macro-level, alternative licensure programs compensate for teachers' shortages in certain subjects by qualifying more people to teach in high-needs areas that have difficulty attracting and retaining teachers. Historically, alternative programs have attracted a more diverse teacher candidate population than traditional programs (US Department of Education, Office of Planning, Evaluation and Policy Development, 2016). According to Kelly and Northrup (2015), the shortage of educators in STEM fields has fueled the popularity and growth of ACPs. LoCascio et al. (2016) conducted a study in low income urban areas in northeastern New Jersey and found 45% of novice teachers participating in an ACP identified as minority. Teachers who use an ACP, however, may feel less prepared. Kee (2012) found first-year teachers with limited education coursework and field experiences felt less prepared than teachers with more complete pedagogical preparation.

Implications and Future Research

This study offers implication for theory, practice, and policy. For theory, the study further illuminates the need for high-quality, diverse, STEM-certified teachers to improve STEM learning outcomes and career pathways for all students, including significantly underrepresented minority students. The results expand the current body of knowledge about certification pathways for minority STEM teachers and identify a viable option to contribute to the broader picture of STEM teacher certification and solve STEM teacher shortages.

For practice, this study informs future teachers, current teachers, teacher preparation programs, and schools and districts. Future teachers and current teachers, as applicable, can discern and find encouragement in multiple pathways to initial and secondary certifications, including the transition from non-STEM initial certification to STEM secondary certification. Furthermore, they might choose to pursue ACP as the most viable option. Teacher preparation programs can educate students about pathways, and schools and districts can promote such pathways. Policy implications at the state or national levels include identifying ACP as a viable option and supporting the expansion of this solution.

The study informs future research to address limitations and further examine STEM minority teacher. This study solely focused on Texas, did not examine student outcomes, and did not account for socioeconomic settings. We recommend replicating this study for a variety of states to determine national relevance and application in solving STEM teacher shortages. Future studies could examine the relationship between performance of minority STEM teachers who pursued ACP pathways with performance of minority students. In addition to teachers preparation and pathways, such studies might examine high-poverty, middle-class, and affluent settings to isolate structural barriers impacting student performance.

This study examined trends in STEM teacher certification by Race or Ethnicity and gender to address minority teacher shortages in Texas, the second largest education authority in the US. Results revealed disparities in Race or Ethnicity among STEM teachers that could dispel the teacher shortage gap if parity were achieved among White, Hispanic, and Black STEM teachers and identified alternative certification programs as the most viable pathway. Increased recruitment and retention of minority STEM teachers through this pathway will dissipate the shortage of STEM teachers. High-quality, diverse, STEM-certified teachers will improve student learning outcomes and career pathways for all students, including significantly underrepresented minority students, leading to a highly skilled and diverse STEM workforce and global competitiveness as a nation.

Availability of Data and Materials

Teacher certification data available from the Public Education Information Management System (PEIMS) through a public information request via the Texas Education Agency available at <https://tea.texas.gov/about-tea/contact-us/public-information-requests>.

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