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Teacher Preparation and Teacher Retention: Examining the Relationship for Beginning STEM Teachers

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Abstract

There have been long-standing concerns about a shortage of science and mathematics (STEM) teachers. Research over the past decades has identified teacher attrition as the primary cause of the shortage of teachers. This is particularly true in high-poverty schools where attrition can be extraordinarily high. The shortage of well-qualified STEM teachers, as well as the high-attrition of such teachers, have negative effects on student achievement. A number of factors influence the attrition rate of STEM teachers, including the preparation experiences of teachers. This study reviews the extant literature describing the relationship between teacher preparation and teacher attrition with a particular focus on STEM teachers and then examines the attrition of beginning STEM teachers in high-poverty schools in Texas by type of preparation program. Consistent with the limited prior research, we find that beginning STEM teachers in high-poverty schools from alternative certification programs that provide limited field experiences and little or no clinical experiences have substantially greater odds of both (a) leaving the profession of teaching and (b) leaving their initial school within a five-year time frame. We also find that the majority of beginning STEM teachers in Texas are prepared by alternative certification programs and beginning STEM teachers from alternative certification programs are more likely than their peers from university-based undergraduate programs to take an initial placement in high-poverty schools. To conclude this study, we examine the implications for policymakers and make recommendations for further research in this arena.

Introduction

For at least three decades, placing well-qualified teachers in every classroom has been a concern for U.S. school leaders and policy makers. There has been a particularly high level of concern about teachers in science, technology, engineering, and mathematics (STEM) and in schools serving high proportions of students living in poverty (high-poverty schools). There has been, in fact, a shortage of both STEM teachers (Cowan, Goldhaber, Hayes, & Theobald, 2016; Wolf, 2015) and teachers serving in high-poverty schools (Ingersoll, 2001, 2004). Not surprisingly, the shortage of STEM teachers is most acute in high-poverty schools (Cowan, et. al., 2016). Indeed, there is a general consensus that students enrolled in high-poverty schools have less access to well-qualified and effective STEM teachers than students in other schools.

The causes of the shortage of STEM teachers in high-poverty schools include both supply and demand factors (Cowan, et al., 2016). With respect to supply, there is increasing evidence the production of STEM teachers is insufficient to meet the demand for such teachers, at least in some labor markets and in some states (Hutchinson, 2012; Ingersoll, 2002; National Academy of Sciences, 2006; U.S. Department of Education, 2002).

With respect to the demand for STEM teachers, a number of studies have found teacher attrition and turnover play an important role in the shortage of STEM teachers (Hutchinson, 2012; Ingersoll, 2006; Kersaint, Lewis, Potter & Meisels, 2012). Regardless of whether the issue is attrition (the teacher leaves the teaching profession) or turnover (the teacher moves from one school to another), research consistently reveals high-poverty schools lose a greater percentage of teachers than other schools—including STEM teachers. This constant loss of STEM teachers in high-poverty schools drives much of the shortage of STEM teachers in such schools. Thus, efforts to address the shortage of STEM teachers in high-poverty schools must primarily focus on efforts to reduce STEM teacher turnover.

As charged by the American Association for the Advancement of Science (AAAS), the purpose of this paper is to examine the relationship between teacher preparation and STEM teacher attrition in high-poverty schools. To accomplish this purpose, we adopt a two-pronged approach. First, we review the available literature on the relationship between teacher preparation and teacher attrition with a specific focus on STEM teachers. In our literature review, we examine both the types of teacher preparation programs and the specific components of teacher preparation efforts (e.g., course, student teaching) in relation to teacher attrition. In this review of the literature, we focus on large scale quantitative research for which results can be generalized to the larger populations of teachers in a state or all teachers in the US. Further, we focus on research that includes statistical controls for the personal characteristics of teachers and the characteristics of schools. We restrict our review of research to such studies because only through the use of such controls can researchers isolate the effects of teacher preparation on attrition and turnover (Boyd, Grossman, Ing, Lankford, Loeb, O'Brien, & Wyckoff, 2011).

Second, we use Texas as a case study to examine differences in teacher attrition between different types of preparation programs. Our primary reason for including the Texas case study is that few studies examine teacher attrition in high-poverty schools. A secondary reason for including the Texas case study is that Texas has created a teacher preparation system in which the majority of teachers no longer complete a traditional undergraduate teacher preparation program. Given the current shortage of teachers, other states may begin to adopt the preparation policies that exist in Texas as a strategy to reduce the shortage.

We commence the remainder of this paper with a review of research that examines the factors that influence teacher attrition. When available, we embed STEM-specific findings. We then focus on the relationships between teacher preparation program (TPP) activities and teacher attrition, teacher attrition in high-poverty schools, and STEM teacher attrition. To illuminate the

relationship between TPPs and teacher attrition, After our review of the literature, we introduce and describe our case study of beginning STEM teacher attrition in high-poverty secondary schools in Texas in order to illuminate the differences in beginning STEM teacher attrition between types of preparation programs. After briefly reviewing our data and methods, we present the results of our case study. We conclude our paper with an implications section for policymakers, researchers, and organizations supporting research in this area.

Examining Teacher Attrition and Turnover

While the focus of this paper is teacher attrition, we also include a discussion of teacher turnover since both can have effects on students in particular types of schools. Attrition is defined as a teacher leaving the teaching profession while turnover is defined as a teacher leaving her or his school, either to move to another school (teacher mobility) or leave the teaching profession (teacher attrition). From the perspective of a student or school, there is no difference between attrition and turnover because the teacher is no longer teaching at the school. From the perspective of the state, teacher attrition is more problematic than turnover because a teacher leaving the profession generally must be replaced.

Recent research suggests about 8% of teachers leave the profession each year and another 8% move from one school to another for a total turnover rate of about 16% (Goldring, Taie, & Riddles, 2014). These annual rates, however, obscures the number of former teachers who return to teaching. This group of individuals—often called the "reserve pool" —can be substantial (Cook & Boe, 2007; Kirby, Grissmer, & Hudson, 1991). Thus, the annual attrition rate of teachers can be somewhat misleading because a relatively substantial percentage of newly hired teachers each year are individuals from the reserve pool (Kirby, et al., 1991). Accurately capturing the size of this reserve pool, however, can be challenging without longitudinal data at the teacher level (Kirby, et al., 1991).

Importantly, attrition and turnover rates vary by school characteristics, particularly with respect to the percentage of students living in poverty in the school (Goldring, et al., 2014). Specifically, in the 2011-12 school year[1], low-poverty schools (those with less than 35% of students living in poverty) had attrition and turnover rates of 7% and 13%, respectively, while high-poverty schools (those with 75% or greater students living in poverty) had attrition and turnover rates of 10% and 22%, respectively (Goldring, et al., 2014).

These attrition rates affect the years of experience of teachers in such schools. For example, In the same academic year, the average years of teaching experience of teachers in low-poverty schools was 14.4 years compared to 12.7 years for teachers in high-poverty schools. Further, 9.3% of teachers in low-poverty schools had less than four years of teaching experience while the percentage was 13.9% for high-poverty schools. This is important given that researchers consistently find that less experienced teachers—particularly those with fewer than four years of teaching experience—tend to be less effective at improving student achievement than other teachers (Borman & Dowling, 2008).

Factors Influencing Teacher Attrition and Turnover

There are a number of factors that influence teacher attrition and turnover, including personal characteristics, school characteristics, school leadership, and the quality of pre-service preparation.

Personal Characteristics. With respect to personal characteristics, younger and less experienced teachers as well as teachers eligible for retirement are much like to leave a school and the profession (Allensworth, Ponisciak, & Mazzeo, 2009; Guarino, Santibanez, & Daley, 2006; Ingersoll, 2001; Johnson, Berg, & Donaldson, 2005; Marvel, Lyter, Peltola, Strizek, & Morton, 2006). Further, teachers of color are more likely to leave their school as well as leave the

[1] This is the most recent academic year for which national data is available.

profession than White teachers (Ingersoll, 2001) while men are less likely than women to leave a school or the profession (Borman & Dowling, 2008). Further, teachers with a graduate degree are more likely to leave (Borman & Dowling, 2008).

Salary. One of the most consistent findings in this area is the negative relationship between salary and attrition (Borman & & Dowling, 2008; Clotfelter, et al., 2011; Podgursky et al., 2004; Hanushek et al., 2004; Kelly, 2004; Stockard & Lehman, 2004). Indeed, the authors note, "higher salaries correlated with reduced odds of attrition" (Borman & Dowling, 2008, p. 390). Importantly, this relationship holds true for beginning teachers as well as more experienced teachers.

School Characteristics. School characteristics are also associated with teacher attrition and turnover. In particular, the percentage of students living in poverty and the percentage of students of color enrolled in the school were associated with teachers leaving the profession (Hanushek, Kain & Rivkin, 2004; Smith & Ingersoll, 2004; Scafidi, Sjoquist, & Stinebrickner, 2007). However, as discussed below, more recent research has called into question these relationships. In fact, these relationships largely disappear once other information about schools is included in analyses. A number of studies have also found that teacher attrition tends to be greater in lower performing schools as measured by student achievement results (Clotfelter, Ladd, Vigdor & Diaz, 2004; Scafidi, et al., 2007). We do not, however, fully understand the reasons behind this association. There is some evidence that teacher working conditions—discussed below—are worse in low-performing schools and these conditions push teachers out of such schools (Boyd, et al., 2011).

Further, research suggests teachers in rural schools are less likely than other teachers to leave the profession while teachers in schools with relatively low enrollment are more likely to leave

teaching (Goldring, Taie, Riddles & Owens, 2014). Again, the causal mechanisms behind these relationships are not well understood.

Working conditions. Perhaps the most important school-related factor associated with teacher attrition and turnover is teacher working conditions. Indeed, a growing number of recent studies have found teacher perceptions of their working conditions are strongly associated with teachers' decisions to leave a school and the profession (Allensworth, Ponisciak & Mazzeo, 2009; Dou, Devos & Valcke, 2016; Ladd, 2011; McConnell, 2017; Simon, & Johnson, 2015). Teacher working conditions include such factors as class size, student load, facilities, materials, supplies, staff collegiality, student behavior issues, and administrative support (Redding & Smith, 2016).

As noted above, the inclusion of information about the teacher working conditions in schools in studies of teacher attrition and turnover result in the "disappearance" of the relationship between student demographics and teacher attrition or turnover. By disappearance, we mean that the relationship is no longer statistically significant after the inclusion of teacher working conditions information in the analysis. For example, in their review of six recent studies of teacher turnover, Simon and Johnson (2013, p1) conclude that the evidence suggests, "teachers who leave high-poverty schools are not fleeing their students, but rather the poor working conditions that make it difficult for them to teach and their students to learn." Research on the relationship between teacher working conditions and teacher attrition or turnover suggests the working condition that has the strongest relationship with teacher intentions to remain at a school is leadership behaviors (Ladd, 2011; Simon & Johnson, 2013).

Teacher Attrition and Turnover in High-Poverty Schools

Both descriptive statistics and research that uses various analytic approaches consistently conclude that teacher attrition and turnover rates are greater in high- than in low-poverty schools.

While there is consensus that high-poverty schools experience greater rates of attrition and turnover, there is less agreement about why these differences exist. A number of explanations have been proposed that focus on the differences in teacher and student characteristics between the two sets of schools (Simon & Johnson, 2013). More recent research suggests differences in working conditions between low- and high- poverty schools influences differences in teacher attrition and turnover (Ladd, 2011; Simon & Johnson, 2013). Despite these research, we still do not fully understand the causal factors that explain differences in teacher attrition and turnover between the two sets of schools.

The primary components of teacher working conditions that have been examined up to this point in time include principal effectiveness, school resources (e.g., class sizes, materials, professional development, salaries), and other school characteristics (e.g., enrollment, geographic location, student characteristics). While there are three primary components, research suggests principal effectiveness is the most influential of these three components in explaining teacher attrition and turnover. As Fuller, Pendola, and Young (2018) note, high-poverty schools employ less experienced and less effective principals as well as experience greater rates of principal turnover. Thus, more than any other factor, current research suggests differences in working conditions between low- and high- poverty schools explain much of the difference in attrition and turnover rates between such schools.

STEM Teacher Attrition and Turnover

In this section, we briefly review the evidence on STEM teacher attrition and turnover rates relative to the rates for non-STEM teachers. We then examine evidence about differences in STEM teacher attrition and turnover by school characteristics.

Attrition and Turnover Rates. Available evidence suggests STEM teacher attrition and turnover rates do not markedly differ from the teacher attrition and turnover rates of teachers

assigned to other subject areas. For example, in their analysis of national data from 2012-13, Carver-Thomas and Darling-Hammond (2017) found STEM teachers had an attrition rate of 7.2% and a mobility rate of 6.1% for an overall turnover rate of 13.3%. These rates were greater than the rates for elementary teachers, about the same for humanities teachers, and slightly less than the rates for English Language Learner and special education teachers. There were not, however, statistically significant differences in attrition rates between STEM teachers and secondary teachers of other subject areas. Using nationally representative data from five previous time points (1988-89 through 2004-05), Ingersoll and May (2012) also found no statistically significant differences in either attrition or mobility rates between STEM teachers and teachers of other subject areas.

Differences by School Characteristics. Using nationally representative data, researchers have also found large and statistically significant lower rates of STEM teacher attrition and turnover for low-poverty schools relative to high-poverty schools (Carver-Thomas and Darling-Hammond, 2017; Ingersoll & May, 2012). Specifically, Carver-Thomas and Darling-Hammond (2017) report STEM teacher turnover in high-poverty schools was 70% greater than in low-poverty schools. Ingersoll and May (2012), in contrast, found no statistically significant relationship between a school's poverty rate and STEM teacher turnover after controlling for the personal characteristics of teachers (race/ethnicity, gender, and age), school characteristics (school level, school size, school locale, student demographics), and school conditions (teacher salary, student behavior issues, administrative support, teacher involvement in decision making, facilities, supplies, professional development related to instruction,, and professional development related to subject area content. In short, once their analysis controls for personal and school factors, poverty rates are no longer associated with teacher attrition or turnover. This suggests that school poverty rates simply serve as a proxy for school

characteristics and conditions. In other words, student poverty is unlikely to be a cause of teacher attrition or turnover, but school characteristics and conditions might be causes of teacher attrition and turnover.

Relationship Between Teacher Preparation and Teacher Attrition

In this section, we review the existing research that examines the relationship between TPPs, teacher preparation program experiences, and both teacher attrition and turnover. As noted previously, we focus on quantitative studies that examine these relationships because quantitative studies allow us to generalize the findings to a broader group of teachers and programs than qualitative studies of groups of teachers or programs. Our selection criteria certainly restricted the number and type of studies included in our review. Indeed, our criteria excluded qualitative studies of teacher preparation program efforts and most of the studies in our review used state administrative data or the nationally representative Schools and Staffing Survey (SASS) data. State administrative data typically includes information that is easily quantifiable such as indicators of completion of student teaching, student teaching placement, number of credit hours completed, or specific types of courses completed. SASS includes teachers' perceptions about their preparation experiences. The SASS questions on this topic are limited and also tend to focus on easily quantifiable aspects of preparation such as types of courses completed or counts of hours. In neither case do the data include information on the details of what occurs in preparation courses or the quality of the experiences in the program. Thus, our review is limited to a relatively narrow slice of the preparation program experiences of students and does not include any subjective judgments about the quality of teacher preparation experiences. We do encourage the reading of qualitative studies of teacher preparation program efforts as such studies provide much more detailed information about what actually occurs in in teacher preparation programs than large-scale quantitative studies.

We could not identify any studies meeting our criteria that examined the relationship between TPPs and beginning STEM teacher attrition or turnover in high-poverty schools. There are, however, a few large-scale quantitative studies of the relationships between TPPs, TPP practices, and both beginning teacher attrition and turnover. We now turn to a review of these studies.

Teacher Preparation Programs and Teacher Attrition

While a number of researchers have focused their efforts on teacher preparation efforts, relatively few such studies have attempted to link the components of teacher preparation programs or the experiences of students in teacher preparation programs with teacher attrition or turnover. There have been, however, a number of large-scale reviews of teacher preparation efforts by experts in the field of teacher preparation (Wilson, 2011). Based on her review of the literature and the Teacher Pathways Project, Wilson (2010) contends the following features are common in effective STEM teacher preparation programs:

- More courses required for entry or exit in their chosen content area (i.e., math or reading);
- A required capstone project (for example a portfolio of work done in classrooms with students or a research paper);
- Careful oversight of the student teaching experiences;
- A focus on providing candidates with practical coursework to learn specific practices;
- The amount of opportunity for candidates to learn about the local district curriculum; and,
- Having student teaching experience, and the congruence between the context of student teaching in terms of grade level and subject area and later teaching assignment (See Wilson, 2011, p. 3).

While these features are associated with preparation program effectiveness, research consistently finds that well-prepared and more effective teachers are less likely to leave a school or the profession (Boyd, et al., 2011).

The majority of studies examining the relationship between TPPs and teacher attrition or turnover have examined either programs in specific states or employed large-scale data sets of of individual teachers who completed different types of TPPs and were exposed to different types of preparation experiences. With respect to TPP type, researchers have divided programs into traditional university-based programs, programs not based at universities, and post-baccalaureate programs. In many respects, there is little difference between the different types of TPPs (Redding & Smith, 2016).

One of the more statistically sophisticated studies[2] examined differences in beginning teacher attrition and mobility by TPPs in Washington State (Goldhaber & Cowan, 2014). While they found statistically significant differences across programs, they found that much of the variation in attrition and turnover rates were limited to the smaller TPPs. The authors did not identify the impact of any specific TPP characteristics on either attrition or turnover. The importance of the study is that researchers identified differences in attrition and turnover rates between TPPs after controlling for other factors affecting attrition and turnover such as the personal characteristics of teachers (race/ethnicity, gender, and age), school characteristics (e.g., student demographics, student achievement, school level, school size, etc.), teacher salary, teacher experience, and the unobserved characteristics of schools. A number of studies have examined beginning teacher attrition and turnover rates for different types of TPPs—particularly between traditional undergraduate programs located in universities and alternative certification

[2] By statistically sophisticated, we reference the statistical methodology employed by the researchers. The authors of this paper employ very rigorous and sophisticated methods to examine attrition and also use a variety of

programs. While there remains debate about the year in which ACPs first originated, the available evidence suggests ACPs first started to prepare teachers in the 1980s (Ludlow, 2011), largely as a short-term response to account for projected teacher shortages, particularly in STEM areas. ACP programs offer a means for expedited coursework and training, greatly reducing the time and costs required for a traditional university-based program (Constantine et al., 2009). Teacher candidates serve as the instructor of record while taking coursework and working with mentors, effectively stacking all components of preparation simultaneously (Humphrey & Wechsler, 2007; Humphrey, Wechsler, & Hough, 2008) and completely by-passing the traditional clinical experience of student teaching under the direction of a cooperating teacher in the school. Not surprisingly, there is great variation in ACP entrance requirements, course order, focus, support, and personalization such that researchers have had difficulty in finding simple categorizations for the structures and content of ACPs (Humphrey et al., 2008). There is a widespread trend across states of creating ACPs and those programs producing an increasing number and percentage of teachers in at least 46 states (Ludlow, 2011). By 2012, the number of ACP teachers had increased significantly such that nearly one-quarter of early career teachers report completing an ACP program (Redding & Smith, 2016).

Early studies of the relationship between different types of TPPs and teacher attrition or turnover found that ACP teachers had indistinguishable or slightly lower rates of turnover than teachers from traditional TPPs (Andrew & Schwab, 1995; Darling-Hammond et al., 1989; Kirby et al., 1989). However, these studies often suffered from limitations such as small samples of particular programs, selection bias, and an inability to control for background and contextual factors that influence teacher attrition and turnover (Guarino, Santibanez, Daley, & Brewer, 2004). More recent research, with much larger samples, has begun to coalesce around findings

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methodological approaches in order to increase the confidence in their findings.

that ACP teachers exhibit higher rates of turnover than teachers from other types of programs, particularly traditional university-based undergraduate programs (Boyd et al., 2008; Boyd, Grossman, Lankford, & Loeb, 2006; Constantine et al., 2009; Decker, Mayer, & Glazerman, 2004; Feistritzer, 2008; Goldhaber & Cowan, 2014; Grossman & Loeb, 2008; Kane et al., 2008).

One of the more comprehensive and statistically sophisticated studies of the difference in attrition and turnover of teachers from ACPs and undergraduate university-based programs was by Redding and Smith (2016). In their study, they used

three waves of SASS data (2000-01, 2003-04, and 2007-08) and a number of personal characteristics, student demographics, and school working conditions to isolate the effect of teacher preparation program features on teacher attrition and turnover (Redding & Smith, 2016). After controlling for the aforementioned factors, the authors found that, relative to their peers from undergraduate university-based programs, ACP teachers had greater attrition and turnover rates. More specifically, Redding and Smith (2016) concluded teachers from ACPs had substantially greater odds of both leaving the profession and of moving to a new school. In an effort to investigate the potential causal mechanisms of these differences, the authors analyzed the teacher follow-up surveys administered in the year after the initial survey. The authors found ACP teachers felt less prepared for their placement as a beginning teacher as well as less supported once they began teaching.

Teacher Preparation Program Practices and Teacher Attrition/Turnover

Unfortunately, we know very little about how teacher preparation practices and teacher preparation program features influence teacher attrition and turnover. A recent body of research has begun to investigate the ways in which variation in preparation practices may contribute to systematic differences in teacher attrition and turnover by instituting different recruitment, preparatory, and placement mechanisms. Below, we review a handful of quantitative studies that

examine specific preparation practices--including coursework and clinical experiences—that influence teacher attrition and turnover. Each of these studies relies on a large sample of teachers—either from a very large school district, an entire state, or a representative sample of all teachers from across the US.

Using nationally representative data, Ronfeldt, Schwartz, and Jacob (2014) examined how curricular courses and clinical experience exposure influenced the longevity of beginning teachers. Using two waves of SASS, the authors estimated how beginning teachers perceived their own preparedness as well as their duration of employment. Similar to prior studies, ACP and TCP programs did not differ statistically in their course and field offerings, reaffirming that there is generally more within- than between-program variation (Ronfeldt & Reininger, 2012). However, nearly one-half of ACPs offered no clinical experience, compared to only 8% of traditional programs. The authors found completion of instructional methods courses (as opposed to content courses) as well as completion of a clinical experience were both associated with more positive perceptions of preparedness and lower rates of attrition. More specifically, they conclude greater amounts of preparation are positively associated with these outcomes.

Of particular note, the analysis suggested the possibility of both threshold and interactive effects. For example, the results suggested 8 to 11 weeks of practice teaching was the minimally significant period for influencing outcomes. Similarly, the results suggested fewer than three methods courses might be insufficient to prepare teachers effectively while more than nine methods courses may have diminishing returns, particularly given that additional methods courses would often result in fewer courses addressing other topics. This was further demonstrated by the result that methods coursework and practice teaching interact negatively such that an increase in one may reduce the effect of the other and supplant it as a trade-off. Indeed, the evidence suggested coursework can substitute for practice teaching and vice versa

such that prospective teachers do not necessarily need the full complement of both areas of preparation. It is important to note, however, that the design of the study did not allow for the identification of causal relationships. Rather, the researchers were able to identify relationships between these variables. Thus, the results are suggestive about the importance of coursework and practice teaching, but there is not enough evidence to draw firm conclusions about these relationships. One might cautiously conclude, then, that there may be minimum levels of coursework necessary to establish an acceptable level of teacher effectiveness while there may be a number of courses beyond which little is gained in terms of increasing the effectiveness of teachers. We would certainly need additional studies to confirm this possibility.

Most pertinent to our study are several findings. First, the results suggested methods courses and practice teaching were of even greater import for mathematics and science teachers than for other teachers. Moreover, this effect was greater in both urban and rural schools—particularly in schools with greater populations of African-American students. Second, the results documented that ACP mathematics and science teachers completed fewer weeks of student teaching and were less likely to complete a practice teaching experience than their peers who completed traditional TPPs. In fact, teachers completing ACP programs were more than 10 times less likely to have participated in practice teaching before becoming a teacher of record.

In a similar study that also utilized a previous wave of SASS (1999-2000), Boe, Shin, and Cook (2007) examined the relationship between the amount of teacher preparation completed and teacher perceptions pof preparedness. We include this study since teacher perceptions of preparedness is positively correlated with beginning teacher retention (Cochran-Smith, Cannady, Mceachern, Piazza, Power, & Ryan (2011). The researchers placed individuals in separate groups with the groups being constructed using the amount of preparation coursework completed. The amount of preparation completed was determined by examining the number of weeks of practice

teaching completed as well as the number of "common components of traditional teacher preparation" (p. 5) completed. Three of the four common components included courses in: selecting/adapting instructional materials; educational psychology; observation of teaching. The fourth common component included the provision of feedback on their teaching. To create three groups based on their preparation experiences, the authors used various combinations of length of practice teaching and completion of four common components of traditional teacher preparation as shown in Table 1.

Table 1: Preparation Program Experience Groups

Amount of Teacher Preparation	Student Teaching	Number of Common Components
Little or No Teacher Preparation	0 weeks	0-3
Some Teacher Preparation	0 weeks	0-4
	1-4 weeks	0-4
	5-9 weeks	0-3
	10+ weeks	0-2
Extensive Teacher Preparation	5-9 weeks	4
	10+ weeks	3-4

The authors used multi-level logistic regression analysis and included individual teacher characteristics (race/ethnicity, gender, and age) and school characteristics (e.g., student demographics, school level, school size, and school locale) to isolate the effects of their teacher preparation measures on teacher attrition. The authors arrived at several conclusions, each of which suggested positive relationships between greater amounts of preparation and various outcome measures. First, the authors found that individuals with more "extensive" preparation

had more positive perceptions about being well-prepared for the job, including being well-prepared to teach the assigned subject matter. Second, the authors found that individuals with more "extensive" preparation had more positive perceptions about being well-prepared for the job, including being well-prepared to manage the classroom. Finally, the authors concluded that individuals with extensive preparation in pedagogy and student teaching reported being better prepared in all areas included in the survey relative to individuals with lesser amounts of preparation. Finally, Ingersoll, Merrill, and May examined the relationship between preparation practices and attrition for all teachers (2012a) and specifically for mathematics and science teachers(2012b). In both studies, the authors utilized the nationally representative 2003-04 SASS data and 2004-05 teacher follow-up study data. Importantly, the survey allowed the researchers to include teacher characteristics (race/ethnicity, gender, and age) and school characteristics (school level, school size, student demographics, and school performance) in the analysis. In this way, the researchers were able to isolate the influence on preparation experiences on attrition and turnover separate from teacher and school characteristics.

For all teachers and mathematics and science teachers, the authors found the type of college, type of degree, and the type of TPP had insignificant effects on beginning teacher attrition. Alternatively, they found the amount of pedagogy courses completed and the length of practice teaching were statistically significantly and negatively associated with teacher attrition even after controlling for the effects of a host of other factors that influence teacher attrition.

Ingersoll and colleagues (2012a) adopted an approach similar to that of Boe and colleagues (Boe, et al., 2007) in which they divided teachers into separate groups based on the amount of preparation experiences completed. The first group of teachers completed one or fewer methods courses, little or no practice teaching, and little or no preparation experiences about selecting materials, educational psychology, or learning theory. Further, they completed

few or no observations of classroom teaching and received little or no feedback about their teaching.

At the other end of the continuum, the group designated as receiving a "comprehensive pedagogy" completed a number of teaching methods courses and completed courses in the selection of instructional materials, learning theory, and educational psychology. Moreover, teachers in this group completed a relatively large number of classroom observations as well as received a substantial amount of feedback about their own teaching.

All else being equal, the authors found STEM teachers receiving little or no pedagogical preparation were more than twice as likely to leave teaching as STEM teachers completing a comprehensive pedagogical preparation. One must remember, however, that such findings are only suggestive of the relationship between pedagogical preparation and retention in the profession. Indeed, the study concludes there is a correlation between pedagogical preparation and retention and but does not claim a causal relationship.

We could find only one peer-reviewed study that examined the relationship between the type of TPP attended (e.g., traditional undergraduate program versus alternative certification program) and STEM teacher turnover. In that study, Ingersoll and May (2012) used the 2003-04 School and Staffing Survey and the 2004-05 Teacher Follow-up Survey to examine the association for mathematics and science teachers. They found pre-service education and preparation of beginning mathematics and science teachers were strongly related to teacher attrition. The authors found college type, degree, and preparation route of the beginning STEM teachers had little impact on their likelihood of leaving teaching after one year. Thus, in contrast to the findings of Redding and Smith (2016), they did not find that teachers from ACPs had greater attrition after one year of teaching. They did find, however, that the amount and type of pedagogical training was strongly related to attrition and turnover over time. In particular, they

found that participation in student teaching was associated with lower odds of attrition. The study, however, was only correlational in nature. Thus, while the study strongly suggests the completion of a student teaching experience was positively associated with beginning STEM teacher retention, the study does not establish that completing a student teaching experience causes increased retention.

The finding that teachers from ACPs do not have differential attrition rates, however, is problematic because many ACP teachers do not complete student teaching experiences or complete courses that include instruction on teaching methods. (Redding & Smith, 2016). Indeed, using some of the same data, Redding and Smith (2016, p. 1113) conclude ACP teachers were, "less likely to have had practice teaching or a course in teaching methods.". Thus, including both the type of TPP and the amount of student teaching could very possibly remove the negative effect of ACPs since teachers from ACPs have greater odds of attrition precisely because they do not participate in student teaching experiences (Ronfeldt, Schwartz, & Jacob, 2014).

Moreover, the Ingersoll and May (2012) study did not consider teachers of other subjects areas and it did not control for school and personal characteristics, which could provide insight into the patterns and trends of teacher retention and TPPs. Our study will continue to build and refine the work on teacher turnover and teacher training programs, focusing on different types of ACPs, school and personal characteristics. In the remainder of this study, we describe the context of our approach, beginning with a brief review of research on differences between ACP and university-based undergraduate programs and concluding with a description of Texas as the location of our study.

Review of Qualitative Studies

While we did not review qualitative studies examining teacher preparation and either teacher attrition or turnover, Cochran-Smith and colleagues conducted an extensive review of the available quantitative and qualitative literature through 2010. As we found as well in our initial search for studies, Cochran-Smith and colleagues found relatively few qualitative studies examining the relationship between preparation program experiences with teacher attrition or turnover.

In their review of 11 studies, the authors concluded that two program features were associated with lower attrition rates. Specifically, these two consistent program features included the following:

> selectivity in the recruitment of appropriate teacher candidates, focusing mainly on their dispositions and commitment to teaching; and, coursework, mentoring, and fieldwork specifically geared toward the contexts in which the candidates would ultimately teach. (p. 24)

The latter finding—specifically regarding coursework and fieldwork—are very similar to the findings of quantitative studies which we discuss below.

Summary of Prior Research

Across the studies included in our review, two program features were consistently found to be associated with lower attrition and turnover rates of beginning teachers. These two factors included coursework and student teaching (sometimes denoted as practice teaching or fieldwork). In general, a greater number of courses completed were associated with lower attrition and turnover rates. However, there is some limited evidence that there is an upper limit to the amount of coursework needed to reduce attrition.

With respect to student teaching, the available evidence suggests completing a student teaching experience as well as completing more hours of a student teaching experience are

associated with lower rates of beginning teacher attrition and turnover. Further, there is some limited evidence that being matched to an effective cooperating teacher is associated with becoming a more effective teacher which, in turn, is associated with lower attrition and turnover rates. The available quantitative studies also suggest that ACP teachers tend to have greater attrition and turnover rates than teachers from traditional undergraduate university-based TPPs. These studies suggest that this finding might be explained by fewer courses and shorter student teaching experiences completed by ACP teachers relative to their peers in traditional undergraduate university-based TPPs.

One major problem with all of the studies we reviewed is that all of them are correlational rather than causal. Indeed, none of the studies were designed to make any causal inferences.

Moreover, none of the reviewed studies included information about either "what" occurred in preparation coursework or the "quality" of that coursework. Without knowing what occurred, we cannot understand the mechanisms through which individuals are better prepared to remain in teaching. Without knowing the quality of the coursework, we cannot make decisions about the most effective quantity of coursework that should be completed. For example, none of the studies tested the possibility that fewer high-quality courses might be equally as effective in reducing the odds of attrition or turnover as a greater number of average- or low-quality courses.

The same criticism can certainly be levied at the research on student teaching, although Goldhaber and colleagues are beginning to identify some specific characteristics of student teaching associated with lower rates of attrition and turnover. Moreover, Goldhaber and colleagues are also undertaking both quantitative and qualitative studies of student teaching that might be able to identify specific practices that are associated with both greater beginning teacher effectiveness and lower rates of attrition and turnover.

Case Study of Texas TPPs and Beginning STEM Teacher Attrition

In this section, we introduce our case study of TPPs and beginning STEM teacher attrition and turnover in Texas. We begin with a review of the state context by examining student characteristics and then school characteristics. We then examine the various types of TPPs in Texas, followed by a comparison of ACPs and traditional university-based undergraduate programs in Texas. We then describe our data and methods before reviewing our findings.

It is important to note that the Texas data on teachers does not identify engineering teachers. Such teachers are classified as mathematics teachers. Technology teachers are somewhat difficult to identify because the wide array of different technology courses. Some courses are included in the Career and Technical Education (CTE) subject area while others are included in the mathematics subject area. The courses in the CTE subject area appear to be more aligned to information technology and the repair of computers. Alternatively, mathematics courses appear to be associated with learning computer languages and coding. Because of the lack of clarity as to which teachers might be considered technology teachers, we omitted such teachers from our analysis. Given the relatively small number of such teachers, the inclusion or exclusion of such teachers in the analyses would have only a marginal effect on our results,

Students and Schools

Texas is a geographically large state with metro areas that have rapidly increasing student populations and vast rural areas with stagnate or declining student populations. The state, then, has a wide array of urban, suburban, town, and rural districts. Further, the student population includes a growing percentage of students living in poverty and a growing percentage of students of Color. In fact, as shown in Table 3, the majority of students are living in poverty and the majority of students are students of Color.

Table 2: Student Demographics in Texas Public Schools by Year (2004-2011)

Student Characteristics	Spring of Academic Year							
	2004	2005	2006	2007	2008	2009	2010	2011
Other	3.2	3.4	3.5	3.6	3.7	3.9	4.1	5.6
Black	14.3	14.2	14.7	14.4	14.3	14.2	14.0	12.9
Latinx	43.8	44.7	45.3	46.3	47.2	47.9	48.6	50.3
White	38.7	37.7	36.5	35.7	34.8	34.0	33.3	31.2
Living in Poverty	52.8	54.6	55.6	55.5	55.3	56.7	59.0	59.2

Because the focus of this paper is STEM teacher attrition in secondary schools, we examine teacher attrition only for middle- and high- school teachers. Further, because our charge was to examine beginning STEM teacher attrition in high-poverty schools, we focus much of our analyses on only teachers in high poverty schools. There exists multiple definitions of high poverty schools. We chose two definitions— schools with at least 50% students living in poverty and schools with at least 75% students living in poverty. We chose these definitions for two reasons. First, the National Center for Education Statistics (NCES) definition of a mid-high poverty school is a school in which between 50.1% and 75.0% of enrolled students participate in the federal free-/reduced-price meal program while the definition of a high poverty school is a school in which between greater than 75.0% of enrolled students participate in the federal free-/reduced-price meal program (McFarland, et al., 2018). Second, in our experience, a commonly held definition of a high poverty school is one in which a majority of students participate in the federal free-/reduced-price meal program. Thus, we employ two definitions as a strategy to address various definitions of a high-poverty school as well as to make comparisons of attrition between the two groups of schools. Making comparisons across the two groups of schools

provides us some insight about the degree to which the concentration of poverty affects teacher attrition and turnover.

Table 4 presents the percentage of Texas public secondary schools as high poverty under two definitions of high-poverty—schools with at least 50% students living in poverty and schools with at least 75% students living in poverty.

Table 3: Percentage of Texas Secondary Schools Identified as High-Poverty by Year (2004-2011)

% of Students Living in Poverty	Spring of Academic Year							
	2004	2005	2006	2007	2008	2009	2010	2011
Middle Schools								
50%+	51.0	54.4	57.9	57.7	56.7	60.2	64.5	64.6
75%+	22.1	24.5	24.9	25.3	26.2	27.4	30.3	30.8
High Schools								
50%+	38.7	41.2	43.0	44.6	44.1	47.9	53.6	57.2
75%+	15.9	17.6	18.1	18.4	18.0	20.3	21.4	23.2

Preparation Programs in Texas

As with other states, Texas universities—both public and private—have long prepared teachers. During the time frame of our study, 67 individual colleges and universities prepared beginning STEM teachers for service in Texas public schools through traditional undergraduate preparation experiences. A number of these colleges and universities also prepared teachers through post-baccalaureate programs as well. Specifically, 64 of the aforementioned 67 entities also prepared teachers through a post-baccalaureate program. In addition, four colleges and universities prepared STEM teachers only through post-baccalaureate programs.

The first ACP in Texas was opened in 1987 with the intent of preparing a greater number of STEM teachers as one strategy to address the shortage of such teachers in the state. In subsequent years, additional programs were opened and also had a primary focus on the preparation of STEM teachers. These programs were initially managed by organizations that were already part of the Texas education system such as school districts or region Education Service Centers (ESCs). Region Education Service centers were created in 1968 to provide services and support to school districts in 20 large geographic regions in Texas. Initially funded by the State of Texas, the Texas Legislature significantly reduced funding in the early-2000s with the expectation that the ESCs would charge fees to school districts and other educational organizations for services. All 20 of the ESCs have created ACPs for teachers in various subject areas. All but four prepared STEM teachers from 2003 through 2010.

Around the same time period, the Texas Legislature created the opportunity for non-education entities to create ACPs. The entities could be either for-profit or non-profit. From 2003 through 2010, 38 privately managed ACPs prepared and placed at least one STEM teacher in Texas public schools.

Shortly thereafter, universities and community colleges were also allowed to create ACPs and prepare teachers for employment in Texas public schools. Over the time frame of our study, 17 colleges and universities as well as 22 community colleges prepared beginning STEM teachers through their ACPs.

The majority of ACPs are to be completed in one calendar year, wherein a candidate obtains a probationary certificate to teach in a school. During the clinical experience year, courses are taken to complete all requirements leading to a standard certificate. These courses vary widely, along with the level of direct interaction, personal support, and content coverage. Certification programs offer courses in a variety of modes, including traditional classroom settings, hybrid,

and fully online formats. The two largest ACPs offer coursework fully online with field supervisors, often staffed by retired teachers.

Differences between Texas ACPs and Traditional Undergraduate TPPs

Existing research suggests there are important differences between ACP and university-based undergraduate TPPs. To begin, alternative certification programs systematically differ in the types of students they recruit. Generally, alternatively certified teachers are often more likely to have experience in working outside of the education field. As a result, many have no teaching experiences, and are less likely to have a degree in education (Cohen-Vogel & Smith, 2007). Early research also found that alternative programs recruit those that come from lower paying technical, support, and service fields (Darling-Hammond, Kirby, & Hudson, 1989; Kirby, Darling-hammond, & Hudson, 1989). However, research has shown there be no significant difference in terms of the selectivity of an applicant's college or entrance scores (Constantine et al., 2009; Redding & Smith, 2016), with some reports demonstrating higher scores for alternative programs (Boyd, et al., 2012). While increased entrance requirements for alternative programs may systematically bias against minority candidates (Guarino, Santibanez, & Daley, 2006), generally alternatively certified teachers are more likely to be racial or ethnic minorities with wider age ranges (Constantine et al., 2009; Gates et al., 2006; Goldhaber & Cowan, 2014; Redding & Smith, 2016). These systematic differences in program recruitment have shown to vary in line with salary, credentials, and other predictors of turnover (Clotfelter, Ladd, & Vigdor, 2011; Goldhaber & Cowan, 2014; Imazeki, 2005).

TPPs can also differ by the type of preparation experiences provided to students (Redding & Smith, 2016). Research suggests ACPs differ from university-based programs in ways that alter teacher's pedagogical knowledge and approach. Following the debate between theory-driven and practical preparation methods, ACPs emphasize preparation during the first year of

teaching rather than with extended coursework and internship experience (Bliss, 1990; Boser & Wiley, 1988; Kee, 2012; Redding & Smith, 2016). In practice, this translates into different curricular foci emphasizing the practical aspects of teacher preparation over theoretical aspects (Redding & Smith, 2016). Consequently, ACPs often provide their students similar or the same courses as university-based program teachers, but the emphases and timing of courses are different than for traditional university-based programs. More specifically, ACPs tend to have a greater focus on pedagogical aspects of teaching, such as classroom management, whereas traditional programs provide more opportunities to also engage in developmental and theoretical courses, such as adolescent development (Boyd et al., 2008).

The more practical focus of ACP preparation experiences often translates into shortened student teaching experiences for ACP students if they participate in any student teaching experiences at all (Cohen-Vogel & Smith, 2007; Constantine et al., 2009). The ACP student teaching experience that do exist often take place in a summer-school context, which often feature significant alterations in terms of student characteristics, curricula, and student expectations than during the traditional school year (Xu & De Arment, 2017). Given that the student teaching component is often cited as the "most important" aspect of teacher preparation (Anderson & Stillman, 2013), with long-term effects on the career trajectory of beginning teachers (Zeichner, 2010), the absence—or reduction—of a supervised student teaching experience is a critical difference between ACPs and university-based programs. As noted above, student teaching experiences have repeatedly demonstrated a significant effect on perceptions of efficacy and preparation (Goldhaber & Cowan, 2014; Lowery & Roberts, 2012; Ronfeldt, 2012; Ronfeldt & Reininger, 2012; Ronfeldt, Schwartz, & Jacob, 2014). It follows that those with quality student teaching experiences have shown greater retention rates as teachers (Goldhaber & Cowan, 2014; Ronfeldt, 2012). Furthermore, programs focusing on more internship style

teaching and methods based coursework have shown to lead to teachers who were more effective, felt more stable, and turnover less (Andrew & Schwab, 1995; Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2009; Ingersoll, Merrill, & May, 2012; Ronfeldt & Reininger, 2012; Ronfeldt et al., 2014).

These differences in preparation also carry over into the characteristics of schools in which individuals complete their student teaching (Goldhaber, Krieg, & Theobald, 2014Ronfeldt, 2012). Student teaching placement options vary significantly by TPP location and research has shown that student teaching placement has a large bearing on where prospective teachers are hired (Cannata, 2010; Engel, Jacob, & Curran, 2014; Goldhaber, et al.,, 2014; Liu, 2007; Ronfeldt & Reininger, 2012). Specifically, individuals are more likely to be hired in schools or districts in which they complete their student teaching experience (Goldhaber, et al., 2014). In addition, the schools that eventually employ individuals as teachers are also very similar in terms of student characteristics and performance as the student teaching placement school.

When combined with locational selection and internship-to-hire match, preparation programs can significantly influence turnover dependent upon how placements fit between personal characteristics and teaching assignment. Research has repeatedly shown that ACP teachers are placed in the most demanding school environments (Boyd et al., 2012; Cohen-Vogel & Smith, 2007; Natriello & Zumwalt, 1993; Redding & Smith, 2016). These high needs environments, combined with shortened training and fewer supportive structures, have shown to significantly influence teacher's decisions on retention and attrition (Ingersoll, 2001). In short, the connection between the TPP, student teaching placement (if any), and placement in a school is important because, as mentioned previously, school characteristic are associated with teacher attrition and turnover.

The above differences identified by researchers using nationally representative data and data from other states are also applicable to Texas. In particular, although candidates enrolled in ACPs may complete a student teaching experience under the supervision of a cooperating teacher, almost all ACP candidates immediately become a "teacher of record" in which they are the only teacher in the classroom with students. This is especially true during the years under study which were prior to the adoption of a new program accreditation process that involved site visits and close scrutiny of program records and processes. While the Texas Education Code required all candidates in every TPP to complete 30 clock hours of field experience prior to becoming a teacher of record, there was no mechanism that ensured program compliance with the statute. In fact, based on data collected by the Texas Education Agency in 2008, greater than 90% of the privately managed ACPs reported requiring fewer than 30 clock hours for field experiences while 83% of community college ACPs and 75% of region education service center ACPs reported requiring fewer than 30 clock hours. Thus, despite state statute requiring at least 30 clock hours of field experiences, a substantial percentage of the ACPs did not require that all of their candidates complete at least 30 clock hours of field experiences.

Table 4: Percentage of Texas Preparation Programs Reporting Selected Ranges of Field Experience Clock Hours (2008)

Preparation Program Type	Number of Hours of Field Experience				
	0	1-29	30-59	60-119	>120
University-Based	0.0	6.1	37.9	24.2	31.8
ACP: District	0.0	0.0	80.0	20.0	0.0
ACP: Region Education Service Center	31.3	43.8	18.8	6.3	0.0
ACP: Private	51.9	40.7	3.7	3.7	0.0

ACP: Community College	11.1	72.2	16.7	0.0	0.0

Source: Texas Education Agency (2008). Teacher Preparation Pre-Service Hours. Austin, TX: Author.

Data

This study relies on administrative data sets obtained from the Texas Education Agency. The data sets for this study are: teacher certification, teacher employment, teacher characteristics, school characteristics, and school achievement. The certification data included the year in which a person obtained initial secondary STEM certification, the TPP in which the person was enrolled at the time of certification, the type of certificate obtained (traditional undergraduate, post-baccalaureate, alternative, or emergency permit), and personal characteristics (race/ethnicity, gender, and age). The employment data included all teachers employed as a teacher of record, the school in which the teacher was employed, the teacher's salary, and the subject areas to which the teacher was assigned to teach. The school characteristic data included school level (elementary-, middle-, or high- school), school size, geographic locale (urban, suburban, rural), and student demographics (race/ethnicity, participation on the federal free- or reduced-price lunch program, special education status, and English Language Learner status). Finally, the school achievement data included the percentage of students passing state-mandated tests in mathematics and reading for each grade level tested (grades 3 through 11). While the data spans 1990 through 2014, we chose to focus on beginning teachers in the 2004 through 2011 academic years and focus on the attrition over a five-year time period for each cohort. One reason for including only these years is that the testing and accountability system remained constant over this time frame.

We focus the study on individuals who are beginning teachers in secondary schools in Texas. We used both certification data and employment data to identify STEM teachers who were in their first year of teaching in a Texas public school. For all but the out-of-state teachers, this also meant that the individual was in their first year teaching. Some out-of-state individuals were also in their first year of teaching while others had accrued experience in other states. Our final samples are displayed in Table 5. Across our eight years, there were 27,717 beginning secondary school teachers employed in public schools. When restricting the sample to schools with at least 50% students living in poverty, there were 16,155 teachers in 1,737 public schools. Finally, when we define high-poverty schools as those enrolling 75% or greater students living in poverty, there were 8,000 teachers in 817 public schools.

Table 5 Number of Teachers and Schools Included in Study

School Description	Numbers of:	
	Teachers	Schools
All Schools	27,717	2,896
% Students in Poverty: 50%+	16,155	1,737
% Students in Poverty: 75%+	8,000	817

Methods

In this study, we employed descriptive statistics and logistic regression analysis. Logistic regression is appropriate when the outcome variable is binary. In this study, there are three different binary outcome variables: being hired in a high-poverty school, remaining in the teaching profession for a fifth year, and remaining employed in the same school for five consecutive years. In all analyses, we controlled for selected teacher characteristics, selected

school characteristics, and for the year in which the individual started teaching. In each analysis, we also included the different types of TPPs intersected with the routes to certification.

With respect to the placement of a beginning STEM teacher in a high-poverty school, our general equation was as follows:

$$\ln(P/(1-P)) = \alpha + \beta_1(IC) + \beta_2(PL) + \beta_3(PT) + Ø_t$$

where P = the probability of obtaining employment as a beginning STEM teacher α = a constant, IC = individual characteristics, PL=program location and context, PT= preparation program type, and Ø = year fixed effect. In non-mathematical terms, this equation reads as: An individual's placement in a high-poverty school is influenced by that individual's personal characteristics, the location and context of the preparation program, and the preparation program type.

With respect to both attrition and turnover, our general equation was as follows:

$$\ln(P/(1-P)) = \alpha + \beta_1(IC) + \beta_2(SC) + \beta_2(PL) + \beta_3(PT) + Ø_t$$

where P = the probability of remaining in the profession or remaining in the same school, α = a constant, IC = individual characteristics, SC=school characteristics, PL=program location and context, PT= preparation program type, and Ø = year fixed effect. In non-mathematical terms, this equation reads as: An individual's odds of remaining in the teaching profession for five years/ remaining in the same school for five consecutive years is influenced by that individual's personal characteristics, the school characteristics of the school employing the individual, the location and context of the preparation program, and the preparation program type.

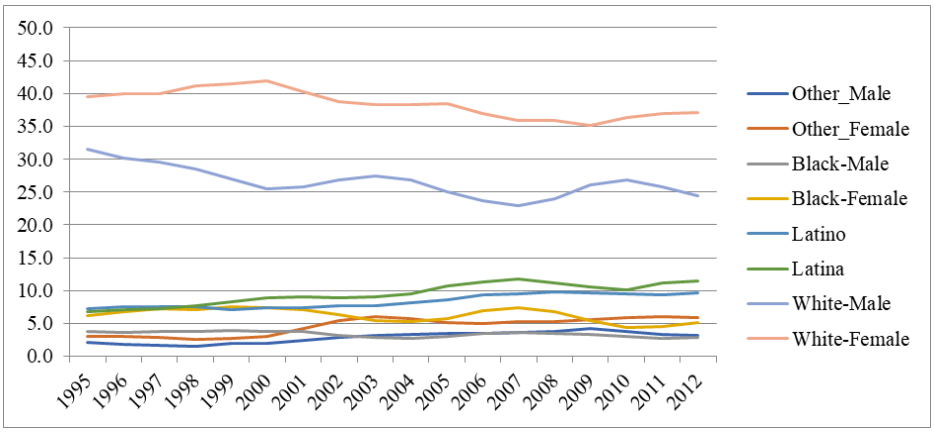
Findings

We divide the findings section into four sub-sections. We begin by examining the racial/ethnic diversity of newly prepared secondary STEM teachers. Next, we examine the racial/ethnic diversity of beginning secondary STEM teachers. Subsequently, we examine the placement of beginning secondary STEM teachers in schools with varying percentages of students living in poverty by the type of TPP and certification route. Finally, we examine the retention in the profession and retention in the same school of beginning STEM teachers in secondary high-poverty schools.

Diversity of Newly Prepared STEM Teachers

As shown in Figure 1, there has been little change in the racial/ethnic demographics of individuals obtaining Texas state certification for teaching secondary mathematics or science classes over the 17-year time frame. The most substantial change was a seven-percentage point decrease in the percentage of White male prospective teachers. There was also a 4.8 percentage point increase in the percentage of Hispanic female prospective teachers. While such changes suggest a move towards greater diversification of the racial/ethnic composition of STEM teachers, the changes are relatively small given that they occurred over 17 years.

Figure 1: Three-Year Rolling Average of the Percentage of Individuals Obtaining Initial STEM Certification by the Intersection of Race/Ethnicity and Gender, 194-2012



Interestingly, as shown in Figures A-1 and A-2 in the Appendix, there were differences in these trends for mathematics and science teachers. Specifically, in mathematics there were very slight decreases of less than three percentage points in the percentage of prospective teachers in five racial/ethnic-gender groups: Black female, White female, Black male, and White male. In contrast, there were slight increases of less than four percentage points for Latino and Latina prospective teachers.

In science, there were much greater changes in the racial/ethnic-gender demographics of individuals obtaining secondary certification. Specifically, over the 17 years, there was an 11-percentage point decrease in the percentage of White male prospective teachers and a 5.6 percentage point increase in the percentage of Latina prospective teachers.

By 2012, there were similar degrees of racial/ethnic diversity for both mathematics and science teachers--specifically, about 62% of prospective teachers for both subject areas were White. However, there were greater changes in the racial/ethnic composition of prospective science teachers than prospective science teachers.

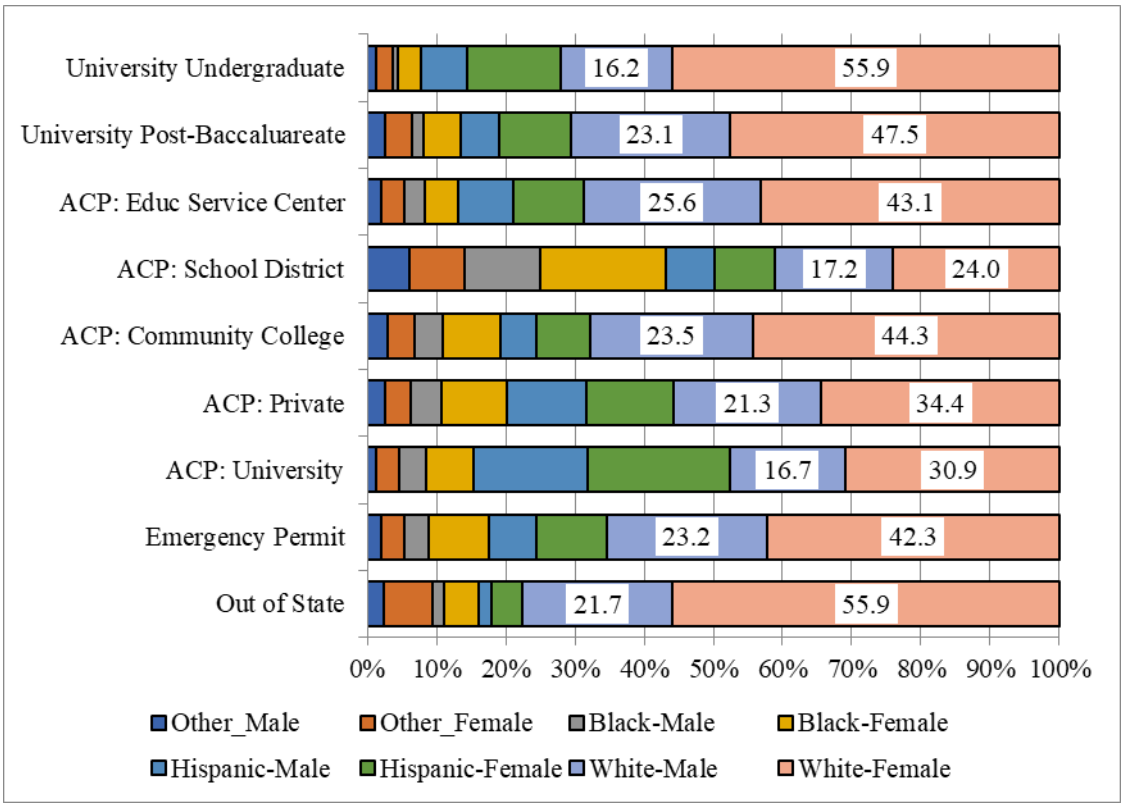
Figure 2 below describes the racial/ethnic-gender composition of graduates from the different types of TPPs and routes to certification (out-of-state and emergency permits).

Four types of TPPs had graduates who were approximately 70% White, including: Traditional University-Based Undergraduate Programs, University-Based Post-Baccalaureate Programs, Region Education Service Center ACPs, and Community College ACPs. In addition, about 70% of individuals obtaining an emergency permit were White. In addition, about 55% of graduates of Private Non-Profit ACPs were White individuals.

Alternatively, two types of TPPs—School District ACPs and University ACPs—had graduates who were predominantly individuals of color. Specifically, about 60% of School

Districts ACP graduate were individuals of color while about 52% of University ACP graduates were individuals of color.

Figure 2: Intersection of Race/Ethnicity and Sex of Newly Prepared STEM Teachers by Type of Preparation Program, 2004-2011



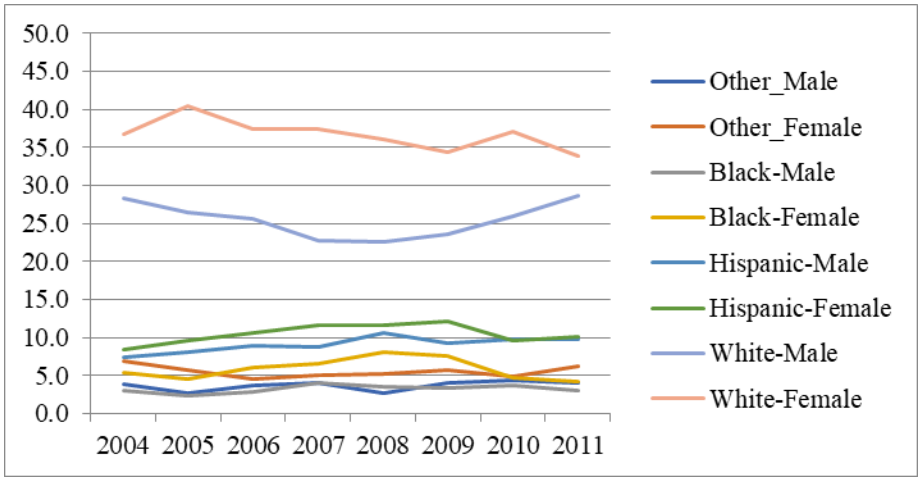
Characteristics of Beginning Teachers

In this section, we review the racial/ethnic characteristics of beginning teachers from 2004 through 2011. As shown in Figure 3, the vast majority of STEM teachers were White. Interestingly, the percentage of beginning STEM teachers who were White slowly decreased from 2004 through 2009 and then rebounded in 2010 and 2011. These last two years of data coincided with the nationwide recession and teacher layoffs in many urban districts in Texas

where many teachers of color were employed. Thus, the recession appears to have reversed progress made on diversifying the STEM teaching force.

There was little movement in the percentage of Black men over the eight years while there was an increase in the percentage of Black women through 2009 and then a relatively sharp decrease from 2009 to 2010. With respect to Hispanic teachers, there was an increase in male teachers over the eight years although the increase was small and gradual. There was an increase in the percentage of Hispanic women through 2009 and then a decrease from 2009 to 2010. Again, the evidence suggests the national recession and concomitant teacher layoffs in urban districts may have had some impact on the racial/ethnic diversity of beginning STEM teachers.

Figure 3: Intersection of Race/Ethnicity and Sex of Beginning STEM Teachers, 2003-2011



Placement of Beginning STEM Teachers

In Table 6 below, we present the percentage of beginning STEM teachers by TPP type for three sets of schools: schools enrolling fewer than 50% of students living in poverty, schools with 50% or more of students living in poverty, and schools with 75% or more of students living in poverty.

Two major trends are evident. First, there was a dramatic increase in the percentage of beginning STEM teachers who entered the teaching profession through ACPs. Indeed, the percentage of beginning STEM teachers from ACPs increased by nearly 20 percentage points for all three sets of schools. Moreover, by 2011, the percentages of beginning STEM teachers in the three sets of schools were 63%, 71%, and 75%. Thus, not only were there dramatic increases in the percentage of beginning STEM teachers who completed ACP programs, but the majority of beginning STEM teachers entered the profession through ACPs.

Second, most of the increase in beginning STEM teachers from ACPs was due to increases in the production of beginning STEM teachers by privately managed ACPs. In fact, for all three sets of schools, there was approximately a 35-percentage point increase in the percentage of beginning STEM teachers who entered the profession through for-profit ACPs. A for-profit ACP is similar to a non-profit ACP such as Teach for America or other well-known non-profit TPPs. Indeed, they appear to be managed and organized in similar manners and approach the preparation of candidates for teaching in similar manners. The only difference is that for-profit programs can seek to make a profit from managing the TPP while a non-profit cannot seek to make a profit from operation of the program.

Table 6: Percentage of Beginning STEM Teachers by Preparation Program Type and Entry into Profession

Preparation Program Type / Route to Entry	Spring of Academic Year								All Years
	2004	2005	2006	2007	2008	2009	2010	2011	
Beginning STEM Teachers in Schools with <50% Students Living in Poverty									
University Undergraduate	23.1	19.7	24.0	25.4	22.6	24.9	23.1	22.9	23.3
University Post-Bacc	12.0	14.4	14.6	10.9	8.8	8.8	6.9	6.0	10.4

ACP: Educ Service Center	23.7	23.3	17.6	15.6	14.9	13.0	12.1	10.7	16.3
ACP: School District	1.6	0.9	1.0	0.8	0.8	0.4	0.3	2.2	1.0
ACP: Community College	7.7	10.6	7.5	6.6	6.0	4.5	4.0	4.2	6.4
ACP: Private	7.9	14.5	20.9	26.8	33.7	38.8	43.0	43.5	28.8
ACP: University	3.9	3.8	5.3	4.1	4.6	3.2	3.5	2.7	3.9
Emergency Permit	12.8	5.8	4.3	2.3	1.6	1.3	1.6	1.5	3.6
Out of State	7.2	6.9	4.7	7.5	7.0	5.1	5.6	6.5	6.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
All ACPs	44.9	53.2	52.3	53.9	59.9	60.0	62.9	63.2	56.4
Beginning STEM Teachers in Schools with 50%+ Students Living in Poverty									
University Undergraduate	19.5	15.9	17.0	17.1	15.9	17.9	17.1	19.7	17.4
University Post-Bacc	10.1	11.6	9.8	7.9	6.9	6.0	5.3	4.6	7.4
ACP: Educ Service Center	18.7	18.8	15.8	13.0	12.1	13.0	12.8	10.7	13.8
ACP: School District	9.2	8.2	9.5	7.8	8.6	7.4	8.2	7.3	8.2
ACP: Community College	6.1	10.8	6.5	5.4	4.7	3.6	2.9	2.9	5.0
ACP: Private	10.5	18.2	25.7	34.2	40.4	42.5	43.0	46.2	35.1
ACP: University	7.9	8.9	8.2	8.2	5.8	4.5	4.1	3.6	6.1
Emergency Permit	12.1	3.7	3.3	1.7	1.8	1.6	1.1	0.9	2.6
Out of State	6.1	3.8	4.2	4.8	3.9	3.5	5.5	4.2	4.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
All ACPs	52.3	65.1	65.7	68.5	71.5	71.1	71.0	70.7	68.2
Beginning STEM Teachers in Schools with 75%+ Students Living in Poverty									
University Undergraduate	14.7	12.5	11.4	13.6	13.4	15.1	13.0	15.4	13.7
University Post-Bacc	7.9	8.3	7.9	5.5	5.0	5.3	4.5	2.7	5.5
ACP: Educ Service Center	17.5	19.1	16.9	13.9	11.8	13.5	13.3	11.3	14.1
ACP: School District	13.7	11.8	13.3	10.0	11.4	11.6	12.4	11.7	11.9
ACP: Community College	5.1	9.0	4.3	5.1	3.9	3.7	3.3	2.8	4.4
ACP: Private	14.9	21.2	30.6	36.9	42.3	42.0	42.6	48.3	37.3

ACP: University	9.8	10.9	10.0	9.8	6.8	5.0	5.1	3.2	7.1
Emergency Permit	10.7	2.9	2.3	1.1	1.8	0.9	1.1	0.9	2.1
Out of State	5.6	4.3	3.3	4.3	3.6	2.9	4.6	3.6	3.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
All ACPs	61.0	71.9	75.2	75.6	76.3	75.8	76.7	77.4	74.8

We make a distinction between the two types of ACPs because the intention of making a profit can incentivize particular behaviors and disincentivize other behaviors. For example, a for-profit ACP would be incentivized to reduce costs as much as possible while maintaining a high-enough level of quality to remain accredited by the state and continue to enroll students. So, for example, a for-profit ACP might want to have a greater number of students per instructor as well as a greater number of students per mentor than a non-profit ACP that is less concerned about earning a profit. Another example would be the amount and type of support provided by a mentor during the candidate's first year of teaching while enrolled in the program. In Texas, for-profit ACPs lobbied the Texas legislature to reduce the frequency with which the TPP mentors had to meet with students in their first year of teaching and to allow virtual observations of teaching. The ACPs were successful in ensuring that certification standards were maintained or lowered rather than increased (Smith, 2014). These efforts allowed ACPs to choose less costly options to meet state certification requirements, thus allowing for-profit ACPs to potentially increase their profit.

In Table 7, we present the results of our logistic regression analysis of the odds of being hired in a high-poverty school. As noted previously, high-poverty schools can be defined in different ways. In this study, we define them in two ways: (1) schools enrolling at least 50% of students living in poverty and (2) schools enrolling at least 75% of students living in poverty. During the time period of our study, Texas schools enrolled a significant percentage of students

living in poverty to such a degree that by the last year of beginning teachers in our study, nearly one-half of secondary schools enrolled at least 50% of students living in poverty.

In the analyses below, we examine the relationships between both the personal characteristics of beginning teachers and the characteristics of the TPPs which the beginning teachers attended with the odds of being hired in a high-poverty school. Importantly, because the personal characteristics of beginning teachers, the number of available openings, and the characteristics of schools vary over time, we also employ year fixed effects to control for differences across years.

Table 7: Odds of Being Hired in a High-Poverty School

Variable	Poverty >=50		Poverty >=75	
Name	Sig.	Exp(B)	Sig.	Exp(B)
Personal Characteristics				
Race: Black	0.000	2.883	0.000	2.761
Race: Latinx	0.000	2.333	0.000	2.755
Race: Other	0.427	0.953	0.000	1.436
Gender: Female	0.937	0.998	0.183	1.045
Age	0.005	1.031	0.861	1.002
Age Squared	0.005	1.000	0.589	1.000
Racial/Ethnic Match: Teacher-Student Body	0.000	0.544	0.000	0.658
Preparation Program Characteristics				
Prep Program: located in metro area	0.005	0.995	0.920	1.000
Region of State: Predominantly Latinx	0.000	11.978	0.000	8.638
Prep Program: Univ post-baccalaureate	0.887	1.008	0.031	1.162
Prep Program: Alt Cert Prog-Region Educ Service Ctr	0.771	1.014	0.000	1.462
Prep Program: Alt Cert Prog-School District	0.000	9.325	0.000	8.865

Prep Program: Alt Cert Prog-Comm College	0.038	1.142	0.000	1.652
Prep Program: Alt Cert Prog-Private Non-Profit	0.013	1.104	0.000	1.483
Prep Program: Alt Cert Prog-University Based	0.139	1.116	0.047	1.171
Route: Emergency Permits	0.584	1.046	0.089	1.197
Route: Out of State	0.340	1.065	0.000	1.502
Academic Year Fixed Effects				
Year: 2004-05	0.000	1.343	0.010	1.222
Year: 2005-06	0.000	1.324	0.021	1.190
Year: 2006-07	0.000	1.315	0.007	1.219
Year: 2007-08	0.000	1.386	0.001	1.286
Year: 2008-09	0.000	1.625	0.000	1.626
Year: 2009-10	0.000	2.170	0.000	1.750
Year: 2010-11	0.000	2.034	0.000	1.877
Constant	0.000	0.463	0.000	0.118

For both sets of high-poverty schools, Black and Latinx beginning teachers had substantially greater odds of being employed in high-poverty schools than their White peers. Interestingly, beginning teachers were less likely to become employed in schools in which the predominant racial/ethnic group of students mirrored their own racial/ethnic identification.

With respect to TPP characteristics, beginning teachers from TPPs located in the two predominantly Latinx regions of the state were substantially more likely to be hired in a high-poverty school. This finding reflects at least two characteristics of these regions. First, these regions experienced rapid increases in the number of students, thus rapidly expanding the number of available teaching positions. Second, the vast majority of the schools in these regions are high-poverty. Thus, this finding is not particularly surprising.

In terms of the type of TPP a beginning teacher attended, graduates from three types of ACP programs had greater odds of being hired in a school enrolling at least 50% students living in poverty. These three types of ACP programs were: school districts, community colleges, and private non-profits. With respect to the odds of being hired in a school enrolling at least 75% of students living in poverty, graduates from all of the TPPs included in the analysis had greater odds of being hired in a high-poverty school than graduates from traditional university-based TPPs. In particular, graduates from school district ACPs had substantially greater odds of being in a school enrolling at least 75% of students living in poverty. This finding reflects that a substantial percentage of the schools in the two largest districts served by these ACP programs—Dallas ISD and Houston ISD—are high-poverty schools. In large part, these programs were "grow your own programs" in which individuals enrolled in the program specifically to teach in these districts. However, a number of the completers of these programs were individuals from the Teach for America (TFA) program. Because of the state certification rules, all individuals must complete a program approved by the Texas Education Agency. Since TFA never applied for approval as a Texas teacher preparation program, individuals in the TFA program completed an approved TPP in order to obtain a Texas teaching certificate. Unfortunately, the state does not identify TFA teachers in its database of certified teachers, thus the number of TFA teachers in these two TPPs is unknown.

Finally, in terms of the years of initial employment as a teacher, beginning teachers in each of the years after the 2003-04 academic year had greater odds of being hired in both types of high-poverty schools. This reflects the increase in the percentage of Texas secondary schools enrolling at least 50% students living in poverty and schools enrolling at least 75% students living in poverty. In short, a greater number of available STEM teaching positions were located in high-poverty schools.

In sum, teachers of color and teachers who graduated from ACPs in general and some particular types of ACPs in particular were more likely to be hired in high-poverty schools. These findings are important in that they provide the context for our analyses of retention in the profession and in the same school below.

Beginning STEM Teacher Retention

In this section, we present descriptive statistics and logistic regression results for retention in the profession and retention in the same school. We begin with descriptive statistics by teacher characteristics and then program characteristics. For our descriptive results, we present information for beginning STEM teachers in schools enrolling fewer than 50% of students in poverty, in schools enrolling at least 50% students living in poverty, and schools enrolling at least 75% students living in poverty.

With respect to our logistic regression results, we present the odds of remaining in the profession and remaining in the same school after year five for beginning STEM teachers in schools enrolling at least 50% students living in poverty and in schools enrolling at least 75% students living in poverty.

Descriptive results for remaining in the profession and in the same school. As shown in Table 8, neither retention in the profession nor in the same school differed substantially by the percentage of students living in poverty enrolled in the school for all teachers regardless of race/ethnicity. Indeed, the differences were less than two percentage points for all teachers across the three groups of schools. For Black teachers, there was little difference in either retention rate across the three sets of schools. For Latinx teachers, the rate of retention in the profession was almost identical across the three sets of schools. With respect to remaining in the same school, the rate was actually greater in schools enrolling at least 50% of students living in poverty than the other two sets of schools. Finally, the rates of retention for White teachers were lower in

schools with greater percentages of students living in poverty. This suggests that, as the percentage of students living in poverty increases, the retention rate of White teachers decreases. This is not the case with either Black or Latinx teachers.

Table 8: Beginning STEM Teacher Retention in the Profession and in the Same School by Percentage of Students Living in Poverty Enrolled in the School

Race/Ethnicity of Teacher	Remaining in Profession					Remaining in Same School				
	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Beginning STEM Teachers in Schools with <50% Students Living in Poverty										
Black	100.0	87.3	81.0	73.8	70.2	100.0	73.1	57.2	38.6	30.5
Latinx	100.0	88.1	82.6	76.6	73.5	100.0	75.0	61.3	44.5	37.6
White	100.0	88.2	80.2	73.0	67.9	100.0	72.5	55.0	37.8	29.1
Total	100.0	87.6	79.9	72.7	67.9	100.0	72.3	55.4	38.2	29.8
Beginning STEM Teachers in Schools with 50%+ Students Living in Poverty										
Black	100.0	89.2	81.4	72.3	68.1	100.0	73.2	55.1	40.6	33.2
Latinx	100.0	89.1	82.4	76.2	73.2	100.0	75.8	60.1	46.2	41.8
White	100.0	86.1	75.2	68.1	62.8	100.0	66.8	45.6	33.0	26.4
Total	100.0	87.0	77.7	70.5	66.0	100.0	70.2	51.0	37.9	31.7
Beginning STEM Teachers in Schools with 75%+ Students Living in Poverty										
Black	100.0	90.6	81.3	72.6	67.3	100.0	75.4	56.0	38.6	27.5
Latinx	100.0	89.1	82.1	75.7	73.2	100.0	76.5	60.4	43.5	35.7
White	100.0	85.7	70.9	62.8	57.5	100.0	69.9	44.9	29.0	20.8
Total	100.0	87.5	76.7	69.0	65.0	100.0	73.3	52.9	36.3	27.9

Table 9 below documents the rates for retention in the profession and retention in the same school rates for beginning STEM teachers by TPP type and route to certification for three

sets of schools. These three sets of schools were those enrolling fewer than 50% of students living in poverty, those enrolling 50% or greater students living in poverty, and those enrolling 75% or greater students living in poverty. Across all sets of schools, ACPs had substantially lower rates of retention in the profession and at the same school than traditional university-based undergraduate TPPs. In general, ACPs and other programs had rates of retention in the profession about eight to ten percentage points lower than traditional university-based undergraduate programs after five years.

Table 9: Beginning STEM Teacher Retention in the Profession and in the Same School by Preparation Program Type and Entry into the Profession

Race/Ethnicity	Remaining in Profession					Remaining in Same School				
of Teacher	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Beginning STEM Teachers in All Schools										
University Undergraduate	100.0	93.4	88.1	82.7	79.1	100.0	75.6	60.2	45.2	40.9
University Post-Bacc	100.0	86.8	79.4	73.1	68.7	100.0	67.8	50.9	36.8	33.2
ACP: Educ Service Center	100.0	86.4	76.1	68.5	63.7	100.0	70.2	49.8	36.1	30.8
ACP: School District	100.0	88.8	68.9	57.1	50.7	100.0	79.0	51.3	35.6	27.0
ACP: Community College	100.0	85.3	76.9	68.6	64.3	100.0	68.1	50.7	35.6	31.1
ACP: Private	100.0	85.5	76.8	69.1	64.4	100.0	69.5	51.6	39.7	32.2
ACP: University	100.0	86.2	77.0	69.3	65.7	100.0	70.0	52.7	37.1	33.6
Emergency Permit	100.0	71.1	65.5	62.2	57.7	100.0	56.0	39.0	28.3	23.4
Out of State	100.0	88.0	78.6	69.8	62.8	100.0	74.5	55.6	39.3	34.0
All Teachers	100.0	87.3	78.6	71.3	66.7	100.0	71.0	52.8	39.1	33.4
Beginning STEM Teachers in Schools with 50%+ Students Living in Poverty										
University Undergraduate	100.0	93.5	87.9	82.4	78.9	100.0	75.3	59.0	44.8	40.0
University Post-Bacc	100.0	87.4	80.4	74.3	69.7	100.0	67.2	50.6	35.5	32.8

ACP: Educ Service Center	100.0	86.1	74.2	67.2	62.8	100.0	68.0	46.0	34.3	27.9
ACP: School District	100.0	88.7	67.7	55.9	49.7	100.0	78.4	49.7	34.6	25.5
ACP: Community College	100.0	84.5	76.5	68.2	62.7	100.0	66.2	47.3	32.1	27.0
ACP: Private	100.0	85.3	76.8	69.0	64.8	100.0	68.8	50.7	38.6	31.0
ACP: University	100.0	87.0	77.4	70.8	66.9	100.0	71.0	52.5	37.3	34.7
Emergency Permit	100.0	69.8	65.3	64.2	59.4	100.0	53.5	36.1	29.5	22.4
Out of State	100.0	86.6	76.7	69.0	61.9	100.0	71.1	50.7	37.1	31.2
All Teachers	100.0	87.0	77.7	70.5	66.0	100.0	70.2	51.0	37.9	31.7
Beginning STEM Teachers in Schools with 75%+ Students Living in Poverty										
University Undergraduate	100.0	93.1	88.8	83.9	81.4	100.0	75.7	61.8	48.3	44.2
University Post-Bacc	100.0	87.5	81.7	73.4	69.2	100.0	70.3	55.7	39.1	36.0
ACP: Educ Service Center	100.0	89.2	73.4	65.8	61.3	100.0	73.3	47.4	35.7	28.7
ACP: School District	100.0	88.4	64.5	52.1	45.8	100.0	77.7	46.2	32.5	21.5
ACP: Community College	100.0	86.2	76.6	68.8	63.6	100.0	66.8	47.0	35.3	30.1
ACP: Private	100.0	85.8	77.2	69.2	65.8	100.0	70.4	52.4	40.1	32.4
ACP: University	100.0	86.6	77.2	71.4	68.7	100.0	70.9	53.8	39.2	37.0
Emergency Permit	100.0	66.9	61.0	59.9	58.7	100.0	57.0	38.4	32.6	29.7
Out of State	100.0	87.9	76.4	67.9	60.3	100.0	73.9	52.7	39.7	32.7
All Teachers	100.0	87.5	76.7	69.0	65.0	100.0	72.1	52.1	39.2	32.7

Below, we present four analyses that examine retention in the teaching profession and retention in the same school within two groups of schools. Both of these are measured in the 5th year of potential employment. So, for example, if a teacher started their career in the 2003-04, we examine if that individual was still employed as a teacher in what would be their 5th year of teaching—the 2007-08 academic year. The same approach was employed in our examination of beginning teachers remaining at the same school. Our two sets of schools are those enrolling at least 50% students living in poverty and those enrolling at least 75% students living in poverty.

Table 10 includes the results for schools enrolling at least 50% students living in poverty. With respect to the personal characteristics of teachers, both Black and Latinx teachers had greater odds of remaining in the profession and in remaining at the same school than their White peers. Similarly, female teachers had slightly greater odds of remaining in the profession and in the same school relative to their male counterparts. Finally, older teachers (those older than age 30) had slightly lower odds of remaining in the profession and at the same school.

Surprisingly, few of the school variables were statistically significantly associated with retention in the profession and the same school. This result may be explained by less variation in the characteristics of students in the high-poverty schools under study. Most noteworthy was the finding that the greater the percentage of students passing all state mandated tests, the greater the odds that a teacher would remain in the profession and in the same school. However, the effects were not particularly strong.

Finally, a number of TPP characteristics were associated with greater teacher attrition and turnover. Most importantly, teachers from each of the TPP types had greater attrition and turnover rates than their peers from traditional university-based undergraduate programs. These results were strong and consistent regardless of the other variables included in the model. Finally, both teachers entering the profession on an emergency permit and teachers entering through an out-of-state program had lower odds of remaining in the profession and in the same school.

Table 10: Odds of Remaining in the Profession and at the Same School after Five Years in Schools Enrolling at Least 50% Students Living in Poverty

Variable	Remain in Profession		Remain at Same School	
Name	Sig.	Exp(B)	Sig.	Exp(B)
Personal Characteristics				

Race: Black	0.000	1.823	0.000	1.841
Race: Latinx	0.000	1.973	0.000	1.668
Race: Other	0.297	1.130	0.332	1.095
Gender: Female	0.009	1.147	0.045	1.086
Age	0.000	1.258	0.000	1.170
Age Squared	0.000	0.997	0.000	0.998
Racial/Ethnic Match: Teacher-Student Body	0.119	1.141	0.005	1.170
School Characteristics				
School Level: Middle	0.000	1.431	0.000	1.496
Charter School	0.065	0.731	0.000	0.444
Z Score of % Black Students	0.098	0.886	0.001	0.890
Z Score of % Students Living in Poverty	0.143	0.841	0.332	0.945
Z Score of % Latinx Students	0.098	0.820	0.427	1.046
Z Score of % mobile Students	0.297	0.908	0.494	1.056
Z Score of % Special Education Students	0.460	0.945	0.513	1.043
School Student Enrollment	0.379	1.000	0.000	1.001
School Student Enrollment Squared	0.632	1.000	0.000	1.000
Z Score: % all students passing all tests	0.039	1.088	0.000	1.379
Preparation Program Characteristics and Type				
Prep Program: located in metro area	0.013	0.990	0.096	0.994
Region of State: Predominantly Hispanic	0.880	0.988	0.008	1.187
Prep Program: Univ post-baccalaureate	0.000	0.489	0.000	0.736
Prep Program: Alt Cert Prog-Region Educ Svc Ctr	0.000	0.350	0.000	0.549
Prep Program: Alt Cert Prog-School District	0.000	0.207	0.000	0.506
Prep Program: Alt Cert Prog-Comm College	0.000	0.343	0.000	0.539
Prep Program: Alt Cert Prog-Private non-profit	0.000	0.411	0.000	0.563
Prep Program: Alt Cert Prog-university	0.000	0.389	0.000	0.635
Route: Emergency Permits	0.000	0.277	0.000	0.472

Route: Out-of-State	0.000	0.437	0.008	0.752
Academic Year Fixed Effects				
Year: 2004-05	0.282	1.150	0.280	1.105
Year: 2005-06	0.811	1.030	0.015	1.239
Year: 2006-07	0.598	0.935	0.981	0.000
Year: 2007-08	0.374	0.895	0.000	1.453
Year: 2008-09	0.223	0.858	0.000	1.473
Year: 2009-10	0.058	0.784	0.708	1.035
Year: 2010-11	0.011	0.718	0.942	0.993
Constant	0.000	0.058	0.000	0.011

Table 11 includes the results for schools enrolling at least 75% students living in poverty. With respect to the personal characteristics of teachers, both Black and Latinx teachers again had greater odds of remaining in the profession and in remaining at the same school than their White peers. Similarly, female teachers had slightly greater odds of remaining in the profession than their male counterparts but the odds of remaining in the same school were not statistically significantly different than male teachers. Finally, older teachers (those older than age 30) had slightly lower odds of remaining in the profession and at the same school.

Table 11: Odds of Remaining in the Profession and at the Same School after Five Years in Schools Enrolling at Least 75% Students Living in Poverty

Variable	Remain in Profession		Remain at Same School	
Name	Sig.	Exp(B)	Sig.	Exp(B)
Personal Characteristics				
Race: Black	0.000	1.823	0.000	2.189
Race: Hispanic	0.000	1.973	0.000	1.906

Race: Other	0.297	1.130	0.709	1.054
Gender: Female	0.009	1.147	0.250	1.069
Age	0.000	1.258	0.000	1.150
Age Squared	0.000	0.997	0.000	0.998
Racial/Ethnic Match: Teacher-Student Body	0.119	1.141	0.257	1.117
School Characteristics				
School Level: Middle	0.000	1.431	0.000	1.471
Charter School	0.065	0.731	0.001	0.394
Z Score of % Black Students	0.098	0.886	0.004	0.785
Z Score of % Students Living in Poverty	0.143	0.841	0.087	0.801
Z Score of % Latinx Students	0.098	0.820	0.518	0.917
Z Score of % mobile Students	0.297	0.908	0.768	1.034
Z Score of % Special Education Students	0.460	0.945	0.413	1.074
School Student Enrollment	0.379	1.000	0.000	1.001
School Student Enrollment Squared	0.632	1.000	0.002	1.000
Z Score: % all students passing all tests	0.039	1.088	0.000	1.391
Preparation Program Characteristics and Type				
Prep Program: located in metro area	0.013	0.990	0.056	0.990
Region of State: Predominantly Hispanic	0.880	0.988	0.283	1.093
Prep Program: Univ post-baccalaureate	0.000	0.489	0.116	0.809
Prep Program: Alt Cert Prog-Region Educ Svc Ctr	0.000	0.350	0.000	0.519
Prep Program: Alt Cert Prog-School District	0.000	0.207	0.000	0.390
Prep Program: Alt Cert Prog-Comm College	0.000	0.343	0.000	0.550
Prep Program: Alt Cert Prog-Private non-profit	0.000	0.411	0.000	0.537
Prep Program: Alt Cert Prog-university	0.000	0.389	0.000	0.612
Route: Emergency Permits	0.000	0.277	0.014	0.610
Route: Out-of-State	0.000	0.437	0.428	0.878
Academic Year Fixed Effects				

Year: 2004-05	0.282	1.150	0.898	1.017
Year: 2005-06	0.811	1.030	0.096	1.234
Year: 2006-07	0.598	0.935	0.987	0.000
Year: 2007-08	0.374	0.895	0.012	1.370
Year: 2008-09	0.223	0.858	0.034	1.309
Year: 2009-10	0.058	0.784	0.410	0.896
Year: 2010-11	0.011	0.718	0.160	0.827
Constant	0.000	0.058	0.000	0.024

As with the prior analysis that examined results for schools enrolling 50% or greater students living in poverty, few of the school variables were statistically significantly associated with retention in the profession and in the same school. The one variable with statistically significant results for both outcomes was the percentage of students passing all state mandated tests. Once again, a greater percentage of students passing all state mandated tests was associated with greater odds that a teacher would remain in the profession and in the same school.

Finally, a number of TPP characteristics were statistically significantly associated with the odds of a teacher remaining in the profession and remaining in the same school. The results largely mirror the results for schools enrolling at least 50% students living in poverty. Specifically, teachers from each of the TPP types had lower odds of remaining in the profession and in the same school relative to their peers from traditional university-based undergraduate programs with only one exception—there was no statistically significant difference in the odds of remaining in the same school between teachers from university undergraduate programs and university post-baccalaureate programs. As with the prior analysis, the odds of remaining in the profession and in the same school were substantially lower than their peers who entered teaching

through university undergraduate programs. These findings are robust in that the results are always highly statistically significant regardless of the set of variables included in the analyses.

Summary of Findings

In this case study, we found graduates of all types of ACPs had lower odds of remaining in the teaching profession for five years than their peers from traditional undergraduate university-based programs. Indeed, graduates from each of type of ACP had odds of remaining in the profession for five years that were at least 50% lower than for graduates from traditional undergraduate university-based TPPs. Our findings held true after controlling for a number of different personal characteristics and school characteristics as well as the year in which an individual was first hired. In particular, graduates of school district ACPs were substantially less likely than their peers from university-based undergraduate programs to remain in the profession for five years. Given that the two largest school district ACPs—Houston and Dallas—served as conduits for Teach for America teachers and such teachers have extremely low retention rates, this finding is not surprising.

Finally, we also found that graduates from all types of TPPs had lower odds of remaining employed for five consecutive years in the same high-poverty school than their peers from university-based TPPs. Again, as with remaining in the profession, graduates from school district ACPs were the least likely to remain in the same high-poverty school over five years. This result stems from the very high attrition rate out of the profession of such teachers.

As noted previously, two of the major differences between university-based programs and ACPs were the completion of a clinical experience prior to becoming a teacher and the completion of field experiences prior to the clinical phase of preparation. While we cannot substantiate the reasons for the differences in retention rate between university-based programs and ACPs in our study, we believe these differences likely explain at least some of the

differences in retention between the two types of programs. Indeed, such an explanation would be consistent with the research included in our review of the literature.

However, the inclusion or exclusion of clinical and field experiences certainly does not explain all of the differences in the retention rates between university-based TPPs and ACPs. Indeed, we found that graduates from university-based post-baccalaureate programs were also less likely to remain in the profession relative to graduates of university-based undergraduate programs for both sets of high-poverty schools and less likely to remain in the same school for high-poverty school when defined as enrolling at least 50% of students living in poverty. This finding is interesting because, unlike ACPs, post-baccalaureate programs required aspiring teachers to complete a clinical experience. Thus, differences in the length of clinical experiences between ACPs and traditional undergraduate university-based programs do not fully explain the differences in attrition or turnover between the two types of TPPs.

Implications for Policymakers

We believe the review of the literature and our study suggests a number of different implications for policymakers. First, and foremost, research suggests beginning teachers who completed some student teaching experience have lower attrition and turnover rates than beginning teachers who did not complete any student teaching experience. Further, the number of student teaching hours completed is associated with lower rates of attrition and turnover... The available evidence also suggests these findings hold true for all teachers across all schools, including high-poverty schools. Despite these findings, we do not yet completely understand the mechanisms behind these findings. Recent research on the student teaching experience, however, provides some clues. For example, Ronfeldt, Brockman, and Campbell (2018) note that student teachers learn from watching their cooperating teacher as well as from the feedback received from the cooperating teacher and the supervising teacher. Indeed, based on their ethnographic

study of six teachers, Rozelle and Wilson (2012) argue that cooperating teachers strongly influence the teaching practices of student teachers. In a study of student teachers in Chicago, Matsko and colleagues (Matsko, Ronfeldt, Nolan, Klugman, Reininger, & Brockman, 2018) found that student teachers feel better prepared to teach when their cooperating teachers model effective teaching and employ effective coaching that includes instructional support, frequent feedback, and useful feedback among other elements. Further, Ronfeldt and colleagues (2018) found that student teachers are more effective instructors when working with a cooperating teacher who is more effective. Similarly, student teachers receive higher observation scores when working with cooperating teachers who receive higher observation scores. In both cases, these findings held true even after controlling for the effects of the personal characteristics of the student and cooperating teachers as well as an array of classroom characteristics. These findings suggest that student teachers are more likely to learn to become better instructors when working with more effective teachers who model effective teaching and provide useful instructional feedback. Clearly further research is needed in this area, but researchers have started to unpack the mechanisms by which student teaching can build the instructional effectiveness of prospective teachers.

Second, based on this review of the literature and state case study, state policymakers could review their current statutes around student teaching for individuals enrolled in ACPs. Based on these reviews, policymakers might consider modifying their statutes based on emerging research in this arena. At the very least, states might consider investing in research in their own TPPs to further explore some of the findings reviewed in this paper as well as elsewhere.

Texas state statute requires ACPs to conduct only three observations of beginning teachers and recent legislation allows ACP employees to conduct observations electronically such that the observer does not have to be in the classroom. Rather than allow such practices to

continue, policymakers might heed research evidence and consider requiring all prospective teachers to complete at least one semester of a supervised clinical experience that provides frequent and useful feedback to the prospective teacher. In Texas, this would require ACPs to provide for a teacher in the school or another educator from outside the school to supervise each beginning teacher and ensure that the beginning teacher receives frequent feedback. This must include frequent observations of the teacher in the classroom.

Third, states could require and enforce the completion of field experiences prior to participation in clinical experiences. While there is less research evidence in this area, our case study suggests the completion of field experiences is positively associated with teacher retention in the profession and in the employing school. While Texas statute required TPP students to complete a minimum of 30 clock hours of field experiences prior to the student teaching experience, many ACPs reported requiring far fewer than the required clock hours. Moreover, even though this requirement has remained in statute for at least a decade, some ACPs continue to report their students do not meet this requirement. Moreover, if the state is unwilling to require far greater levels of supervision of beginning ACP teachers, then the state could dramatically increase the number of field experience clock hours required prior to becoming a teacher.

Finally, policymakers could fund both efforts to collect far more information about preparation program experiences and research to utilize the data to understand more completely the relationship between TPP experiences and beginning teacher attrition and turnover. While legislatures often appear reluctant to expend money on such efforts, any improvements in teacher retention stemming from such research can result in improvements in student outcomes and substantial cost savings for districts—especially those with high-poverty schools. We now turn to discussing such research efforts.

Challenges to Researching the Relationship between

Teacher Preparation and Teacher Retention

There are numerous challenges to researching the relationship between teacher preparation and teacher retention. Most of these challenges are not unique to research on STEM teachers.

Retention of Teachers by Teacher Effectiveness

While the retention is the focus of this particular study as well as the studies included in our review of the literature, the issue of improving retention rates is more complex than simply determining which facets or experiences of teacher preparation are associated with greater retention of beginning STEM teachers or greater retention of STEM graduates placed in high-poverty schools. Indeed, what we need to understand and identify is the facets and experiences of TPPs that are associated with greater retention of *effective* STEM teachers in high-poverty schools. The addition of effective greatly complicates the issue as one would need to define "effective" when examining this relationship.

While many subscribe to a narrow view of teaching and teacher preparation focused on improvements in student achievement as measured by test scores, other argue for a much broader view that includes a variety of non-cognitive outcomes including the development of morally and socially just students. Not only is there a lack of consensus about the goals of teacher preparation, the extant goals are not always clearly delineated (Tatto, et al., 2016). The lack of consensus and clarity in these areas impedes the development and implementation of research agendas. Indeed, greater consensus and clarity is necessary, but not sufficient, to move teacher preparation research forward, particularly as the research agenda relates to the preparation of STEM teachers in general and STEM teachers serving in schools with high proportions of students living in poverty in particular.

Connecting the Chain of Evidence

A second challenge to studying TPP practice and teacher retention is data collection. To isolate the effects of TPPs on retention, researchers need access to data on all the other facets of the educational system that influence teacher retention. Much of this data is related to teacher characteristics (e.g., personal characteristics and salary) and the schools employing teachers (e.g., student demographics and school-level achievement). Many such data elements are easily available from state education agencies. However, recent research has shown that teacher perceptions of their working conditions are strongly associated with teacher retention in the school and in the profession. Many states do not have such data at even the school level and the states that do have such data have collected it anonymously such that researchers could not connect the perceptions of an individual teacher to other information about the teachers such as TPP attended or certification scores.

Lack of Common Definitions and Data Collection

A third challenge is a lack of common data collection efforts with common definitions of the data to be collected. Indeed, outside of the commonly used SASS data, researchers use a wide array of data collection methods and define data elements in different ways. This makes the development of a research consensus about the TPP practices associated with greater beginning teacher retention far more difficult to achieve.

Recommendations for Further Research

To examine fully the relationship between TPP experiences and teacher retention, researchers would need to collect data in at least five different areas related to the preparation, placement, and retention of beginning teachers. These areas include the basic components of teacher preparation programs: student selection, inputs to program, course content, course pedagogy, characteristics of faculty/instructors, characteristics of peers, field experiences, student teaching experiences, characteristics of cooperating teacher, characteristics of supervising

teacher, job placement, teaching effectiveness, and retention. Collecting such data will start to provide a comprehensive portrait of the teacher preparation program process. Such information has historically been a black box filled with critically important processes without any collection of data.

We present these five areas in Table 12 below. In the table, the first column includes the name of the area and the second column includes some, but not all, of the possible measures in the area. The third column includes the data sources that would provide the information on the measure and the fourth column provides the time (frequency) of the data collection.

In short, data collection would need to commence during the application to admission into a TPP, continue throughout individuals' experiences in the TPP, and end only after the individual leaves the profession or remains in the profession through year five. This would be a monumentally complex and expensive effort that would necessarily span nearly a decade of data collection for each cohort of prospective teachers. Preparation programs, school districts, and states would necessarily need to partner in this endeavor as each entity would need to collect and report data.

Research on a shorter timeline could commence by identifying individuals entering the teaching profession and collect information about their TPP experiences through surveys. While such research should certainly be undertaken, such efforts would not yield the detail garnered in a more complex and involved research effort that actually follows individuals from TPP entry to teaching in a school.

Table 12: Areas of Data Collection for Researching

Teacher Preparation Programs and Teacher Retention

Area	Possible Measures	Data Sources
Pre-Conditions	Admission criteria	Program documents
	Commitment to profession	Survey of admitted students
	Dispositions	Survey of admitted students
	Prior instructional experience	Survey of admitted students
	Personal characteristics	Survey of admitted students
Program Inputs	Instructor characteristics	Program documents/data
	Class sizes	Program documents/data & surveys
	Funding levels	Program documents/data
	Materials/supplies	Program documents/data & surveys
	Facilities	Program documents/data & surveys
	Tuition/financial support	Program documents/data & surveys
Preparation Program Experiences	Course content	Program documents/surveys
	Field experiences	Program documents/surveys
	Teaching knowledge and skills	Assessments of knowledge and skills
	Instructional ability	Videos, observations, surveys
	Sense of self-efficacy	Survey of students
	Quality of courses/instruction	Survey of students/observations
Clinical Experiences	Length of experience	Program documentation
	Quality of experience	Survey of students/supervisors
	Feedback from supervisors	Survey of students/supervisors
	Setting characteristics	State data & student surveys
Placement	School characteristics	State administrative data
	School achievement	State administrative data
	Mentoring/coaching	Survey of teachers / school personnel
	Working conditions	Survey of teachers
	Characteristics of assignment	Survey of teachers / school personnel

	Instructional ability	Teacher evaluation scores
	Sense of self-efficacy	Survey of students
Teacher Effectiveness	Measures of effectiveness	Test scores, observations
Retention	school teacher retention rate	State administrative data
	Reasons for staying/leaving	Survey of teachers

Within these five areas, the most difficult and challenging area regarding data collection is the TPP experiences. Collecting information in this area could include the administration of surveys of both students and instructors, creation of detailed documents describing the actual content and instructional experiences in courses, observations or video recording of courses, and logs by instructors and students. Such data collection would require a relatively substantial amount of time and resources and, therefore, would certainly require significant external funding to accomplish.

The creation and adoption of common data collection definitions and procedures and definitions would be critical to conducting the type of large-scale research that would allow for generalizations to be made across multiple instructional settings. Thus, researchers with extensive experience in conducting such research could identify the details of such data collection. To begin, an external funding agency could convene a relatively small group of scholars to sketch out the parameters of both data collection and data definition efforts. A wider group of scholars could then review the documents created and provide detailed reviews and suggestions to the core group of scholars. After the initial review and revision of the preliminary document, a larger group of scholars could convene and produce a final report that details: data collection procedures, lists of data elements, and definitions of the array of data elements. The

document could be made publicly available so all researchers could have access to the information.

To follow up on this effort, external funders could create competitive grant processes for researchers and states. Researchers and states could create a partnership such that the state assists with the extensive data collection efforts and the researchers analyze the data and produce reports. The inclusion of state education agencies in this effort is important given the vast array of data that would need to be collected to extend our knowledge about the relationship between TPP experiences and beginning teacher retention, including beginning STEM teacher retention.

Finally, programs and states would need to invest in building the data collection infrastructure as well as building the capacity of individuals to properly collect these vast amounts of data. These steps cannot be ignored. Indeed, the effort to conduct this type of research on teacher preparation programs would hinge entirely on the data collection infrastructure and the knowledge and skills of those tasked to collect the data.

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