Pre-Service Science Teacher Attrition: Critical experiences, relationships, and timing

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Attracting, retaining, and graduating qualified science teachers are well-documented challenges. Via a sequential explanatory mixed methods study, we followed the educational route of 10 years of secondary science teaching candidates. Descriptive statistics were analyzed with particular attention to the timing of attrition when it occurred. Interviews were then conducted with students from the different outcome groups and researchers used content analysis to identify common themes. We found that attrition, both from the sciences and from the educator preparation program (EPP), occurred quickly—often before traditional support and engagement structures within the program would have had time to work. Our findings conclude that specific institutional supports, mentoring support, and peer relationships directly affected students’ persistence. In particular, participants who engaged in an NSF grant-sponsored mentoring program demonstrated dramatically higher persistence rates than traditional EPP participants. We conclude with a list of actionable steps programs might take to support and engage science-teaching majors prior to the timing of peak attrition.

Keywords: attrition; engagement; science teacher preparation; mentoring

Introduction

Nationwide, the number of undergraduate students who earn educator certification or major in education has decreased since 1970 (Possy, 2018) and mirrors the consistent annual increase in teachers who leave education (Sutcher, Darling-Hammond, & Carver-Thomas, 2016). In STEM teaching fields specifically, as the supply of quality mathematics and science teachers languishes, the demand for professionals in mathematics and the sciences continues to rise (National Academy of Sciences, 2010; Watt, Richardson, & Pietsch, 2007). This puts pressure on both K-12 and post-secondary educational structures to recruit and retain mathematics and science teachers with the pedagogical content knowledge and the classroom efficacy to excel and persist.
in the STEM classroom (National Research Council, 2011; National Academy of Sciences, 2010).

This research study is framed at the intersection of the fields of science education and research in student engagement and retention. Following the framework put forward by Wang and Grimes (2000), we designed research questions consistent with their iterative growth approach to attrition research, but focused on a population of particular import. Specifically, we examine these research questions:

*What pre-service science teacher attrition patterns exist at our public regional comprehensive university?*

*What social and experiential factors influence undergraduates pursuing science teacher certification to change majors, not certify, or choose other certification pathways?*

*What is the timing of major change or change in certification pathway, if it occurs?*

We believe that the best prospect for addressing the STEM teaching shortage is by attending to specific dropout predictors and the ongoing relationships that shape students’ perceptions of these situations, attending to the timing of critical points and relational influences on career and major choice. Our mixed methods study begins by an analysis of all declared science teaching majors over the past decade, attending to their persistence pattern in science, their persistence pattern in education, and the timing of any change in course. We identified a stark success rate disparity between students in the Robert Noyce funded NSF STEM teacher recruiting and support program, and students outside the program. Students in the program exhibit four times the likelihood to graduate certified to teach science as those outside the program.

Following our data analysis, we interviewed and analysed students who were a part of three key outcome groups: science teaching majors who left the sciences, science
teaching majors who persisted in science but left teaching, and science teaching majors who persisted in science teaching. The influences of peers, mentors, and faculty, either toward staying or leaving, appeared repeatedly in the qualitative analysis of interview data.

**Literature Review**

The National Academy of Sciences (2007, 2010) has warned repeatedly of our nation’s desperate need for a STEM workforce that will keep pace with project growth in demand, and specifically the shortage of highly qualified STEM educators capable of engendering the interested and cultivating the expertise this next generation of STEM professionals will need. The challenges facing institutions seeking to attract and retain aspiring science teachers are myriad: increasing economic impact of student debt and the rising costs of higher education (Sutcher et al., 2016), an increase in for-profit teacher certification entities, teacher salaries that do not keep up with the cost of living, hyper-accountability organizational structures and micromanagement of teachers, decrease in state and federal education budgets, increased federal and state assessment both in teacher education and in public schools, federal and state political rhetoric that disrespects and commodifies the profession of teaching and public schools, and political efforts to privatize education nationwide (Betancourt, 2018; Zeichner, 2010).

In one instance of the staggering costs related to this endeavour, the Texas Center for Educational Research released a study in 2000 estimating the costs of teacher turnover to the state at somewhere between $300 million and $2.1 billion per year. Had the analysis included the state’s costs for training prospective teachers who never certify or enter the classroom, the cost would have been markedly higher.

More hopefully, Watlington, Shockley, Guglielmino, and Flesher (2010) analyze a large volume of teacher turnover research and conclude that much of it is avoidable
given appropriate training and support. Hong, Greene, Roberson, Francis, and Keenan (2018) examined pre-service teacher’s processes of choosing and committing to a teaching career. Their research findings indicate that their participants’ pathways to choosing and persisting to teacher certification were complex, non-linear, and evolved with social and environmental contexts. They also indicated that the developing personal identity of pre-service teachers was intrinsically connected to their choice of teaching as a career. They state,

[T]he process of pre-service teachers’ career exploration inevitably involves the exploration of various considerations such as sociocultural conditions (e.g. the levels of support from family to friends, financial benefit, and societal perception of the teaching career), specific tasks embedded in the social context (e.g. teaching experiences in formal or informal educational settings, learning experiences in teacher education programs), one’s own psychological attributes (e.g. self-efficacy and value orientation).

(Hong et al., 2018, p. 410)

They argued that prospective teachers need to receive constructive feedback from practitioners they trust. Other research concurs that such support, paired with early exposure to the teaching profession, would improve persistence to graduation (Day, Sammons, Stobart, Kington, & Quing, 2007; Smith & Ingersoll 2004; Darling-Hammond, 2010).

Wang and Grimes (2000), researching in the area of college student retention rather than education, framed retention research in terms of three elements: determining dropout predictors, identifying critical points, and validating outcomes assessment of retention endeavors. Their work built on the work of Levitz and Noel (1985) in aspiring to identify precisely timed interventions for specific subpopulations of students. If the STEM teacher shortage is to be addressed, there must be measurable and attainable steps identified toward the lofty goals of a robust professional community. Wang and
Grimes’ elements provide a measurable, step-by-step frame for the vocational exploration and interpersonal sense-making recommended by Hong et al. (2018) and Day et al. (2007).

In her dissertation, Groves (2019) concluded that Hispanic STEM teacher candidates were best served by multiple systems of support including peer support, family support Master Teacher support, programmatic support, and financial support. Kuh, Kinzie, Cauce, Shoup, and Gonyea (2006) conclude that the same is true for all college students, arguing robust support systems involving faculty, mentors, and peers benefit all students, and particularly students from historically underserved populations. The findings both Groves and Kuh et al., however, remain largely silent on the timing of these supports. Specifically, how long does an institution or a program have to establish engaging support systems with a particular student before that student is likely to leave?

Once pre-service teacher candidates enter the classroom, the character of their preparation continues to have an impact. Latham, Mertens, and Hamann (2015) examined attrition data from over 6,500 teachers in Illinois and found that those teachers prepared through Professional Development Schools persisted at a markedly higher rate than those traditionally prepared. More broadly, Ingersoll, Merrill, and May (2012) examined differences in teacher preparation methods nationally and how those differences affect teacher retention. Their research findings indicate that STEM teachers are more likely to pursue alternative certification routes with lower quality pedagogical content training, and have lower retention rates once they enter the teaching field. Alternative certification pathways often have less field experience and fewer opportunities for candidates to get quality, discipline-specific feedback and mentoring as they pursue their teaching certificate. Ingersoll et al. (2012) found that 24.5% of
teachers who have little or no disciplinary pedagogical training leave teaching after one year, compared to 9.8% of teachers who have had a comprehensive pedagogical training. This study may indicate that the absence of a STEM specific EPP at a university contributes to the attrition levels of STEM teachers not only before graduation but also after they enter the profession.

Digging into what specific benefits these programs might provide, Hong’s 2010 study attempted to identify specific aspects of pre-service and beginning teachers’ professional identities in relation to what caused them to leave the profession. Hong identified six factors: value, efficacy, commitment, emotions, knowledge and beliefs, and micropolitics, through a mixed-methods study that included participant surveys, then interviews of participants at different stages of teaching. Hong concluded that teacher candidates tend to have much more vague concerns about teaching, while in-service teachers tend to have much more concrete concerns. This raises the related question of which specific interventions might best assist teacher candidates in anticipating and preparing for the more concrete concerns of their future colleagues. Still these studies rely largely on general characterizations of the teacher candidates’ educational experiences, while Wang and Grimes (2000) recommend very specific time-bound identification of issues for specific subpopulations.

In a recent study of STEM majors’ and graduates’ attitudes towards pursuing a teaching by Marder, Brown, and Plisch (2018), STEM majors indicated that in order to pursue a teaching career through a university, they would need (1) financial incentives, (2) faculty in content departments to discuss a teaching career as a positive career choice, and (3) more information about teaching salaries and benefits. This research points to specific interventions for universities seeking systemic improvement in
recruiting and retaining STEM teaching candidates. Marder et al. (2018) recommended that university EPP’s and disciplinary departments

Impress upon university faculty and advisers in STEM disciplinary departments the importance of promoting middle and high school teaching with their undergraduate majors and graduate students, and of providing them accurate information about the actual salary and positive features of teaching (p. 27).

The survey respondents in the Marder et al. study indicated that they would be more interested in pursuing a teaching career if there was access to a STEM specific teacher certification program at their university, if teachers earned a higher salary, if there were student loan payoff, tuition, or scholarship incentives attached to getting teacher certification, and if the teacher certification added less time to their degree plan. These factors likely contribute to the attrition rate of STEM majors from EPP programs at most universities. These studies highlight the need for additional work to identify events and critical points that influence attrition while attending to relational supports that foster persistence.

**Conceptual Model**

In the field of higher education retention, Levitz and Noel (1985) proposed a popular theoretical framework, based on Forrest (1982), which conceptualized retention research as inextricably connected to action. Their six objective framework was:

1. To study success – to find out what the institution is doing well in order that it may do more of it;

2. To pinpoint campus services that need further attention so that they may be improved;

3. To determine the type of intervention programs and practices that are linked to student success and student persistence;
4. To follow those students who receive special attention or participate in special programs to determine whether the intervention is having the desired impact;
5. To target students who will benefit from interventions known to have a positive impact;
6. To provide validation of the outcomes that an institution is striving to achieve (Levitz & Noel, 1985, p. 350).

Wang and Grimes built on this framework by identifying three major components within retention research: determining dropout predictors, identifying critical points, and validating outcomes assessment of retention endeavours. The wrote, ‘Retention research should promote a spirit of continual improvement instead of just seeing what went wrong … the data gathers should serve as a catalyst for intervention as well as for administrative policy making.’ (2000, p. 61)

**Methodology**

The Wang and Grimes (2000) framework lends itself to an explanatory mixed methods approach. Initially, we gathered student performance data captured for all university students to identify dropout predictors and the timeframes in which particular attrition patterns most frequently take place. However, the Wang and Grimes framework also recommends examining non-cognitive factors such as social motivation and receptivity to institutional support services, which are better identified through interviews and qualitative data analysis rather than institutional datasets.

Since our framework culminates in ‘validating outcomes assessment,’ it again seemed reasonable to begin with a quantitative examination of groups that had either participated or not-participated in an intervention we believe would positively affect retention. Just as critical to our analysis are qualitative data such as student beliefs about
the characteristics of their intended career and about their perceptions of obstacles they encountered in their academic journey.

Our methodological framework allowed us to examine aggregate science major quantitative data, then move to a qualitative analysis of a small cross-section of those students to ‘explore the participants views in more depth’ (Ivankova, Creswell, & Stick, 2006, p.9). An IRB was obtained at the university where the study was completed to ensure the protection of student rights.

**Context and Participants**

This research was undertaken at Stephen F. Austin State University (SFA), a rural comprehensive university which was founded as a teacher’s college in 1923. With an enrolment of roughly 13,000, approximately 50% of SFA graduates report being the first in their family to graduate from college, and just over 70% of STEM majors qualify as Pell Grant eligible. The university offers undergraduate science certifications in Biology and Chemistry. At the time this research was undertaken, these certifications include a major in biology or chemistry taught exclusively by the Department of Biology or the Department of Chemistry, respectively, then eight additional courses in an Education Preparation Program (EPP) taught exclusively through the College of Education. The traditional EPP pathway included mandatory field experience in six of the eight courses but did not include an early intense field experience component, consistent mentoring by faculty or mentor teachers, or a peer support network.

The National Science Foundation program Talented Teachers in Training for Texas (NSF 1136416, NSF 1556983), T4 for short, is a Robert Noyce Scholarship initiative based at SFA and with the goals of:
1. Creating experiences through which university STEM majors can examine careers in high school teaching through early intensive field experience (Hubbard, Embry-Jenlink, & Beverly, 2015);

2. Targeting aspiring STEM teachers for authentic engagement in a community of practice with a structured mentoring network (including experienced classroom teachers, aspiring STEM teachers, and STEM and education university faculty) for two years before graduation and three years after entry into the teaching profession (Hubbard, Embry-Jenlink, & Beverly, 2013);

3. Longitudinally examining prospective STEM teachers for the purpose of identifying most effective practices in long-term STEM teacher training and retention.

T4 Scholars are STEM majors who apply to the program and are selected based on GPA, professor recommendations, essay, time to graduation, and responses during a face-to-face interview. Attention was also paid to recruiting scholars for whom teaching had not been their original career intention and who would add to the diversity of the overall program.

During their undergraduate coursework, T4 pre-service teachers receive biweekly mentoring and training while undergraduates, regular mentoring from STEM and education faculty members, a STEM expert supervising teacher during student teaching, induction mentoring once they enter the classroom, and sizable scholarships equivalent to roughly three years’ tuition. T4 Scholars commit to regular participation in the mentoring network community and four years of teaching in a high-need school district. Scholars also have opportunities to attend discipline specific state conferences as well as regional and national Robert Noyce Conferences.

**Course Grade and Persistence Data**
Our initial data gathering included quantitative academic performance data for all biology and chemistry majors who had attended SFA since 2007 and who had at some point identified secondary education as a minor or emphasis. For these 97 students, we tracked graduation rates, secondary education courses taken, and majors and minors declared or completed. We also gathered parallel data for all mathematics teacher majors, believing this to be the most similar teaching population within the university and hoping to use that population’s attrition patterns might serve as a reference point for pre-service science teacher attrition patterns.

Our framework called for specific attention not only to what predictors of attrition existed, but also when particular attrition patterns took place. Since different students started in different academic years, we measured time units in either semesters since beginning at the university or number of courses, depending on the context of the variable.

Finally, we also obtained data from the Texas Education Agency (TEA) to identify which science and math teaching majors went on to teach in a Texas public school setting, even if they did not get certified at SFA.

This quantitative data analysis led us to identify three emergent groups with differing characteristics based upon persistence to graduation or certification, these groups were:

1. Science teaching majors who had persisted to certification and a degree in major;
2. Science teaching majors who had persisted to a degree in major without certification; and
3. Science teaching majors who had not persisted to degree in major.

Student Interviews
To more thoroughly understand what influenced science teaching majors toward persistence or change of major or career, and to more adequately understand their perceptions, we conducted interviews with individuals representing each of the identified three key groups of students from the data analysis.

Interviewees were selected from three identified categories based on the descriptive data analysis of the 97 science majors. Within each category, interviewees were contacted in order of most recent enrolment at the university. This criterion was intended to maximize the relevancy of feedback to current university programs and shortcomings, as well as to maximize the likelihood potential interviewees would respond to a request for an interview. If a potential interviewee did not respond after three attempted contacts, they were replaced with the next most recent candidate in that category.

Seven individuals were interviewed by three different faculty members using the same semi-structured interview questions. Interview questions (see Appendix) were designed to identify critical experiences within candidates’ educational journeys, along with how they interpreted those experiences. The questions were based upon the theoretical framework of Wang & Grimes (2000) and designed to identify key points in persistence or attrition for the participants. We focused particularly on challenges during the students’ certification pathway, and what influences had positive or negative impacts on their choices to persist in STEM teaching, and how those influences helped the participant’s choose to not certify to teach, or choose another major. Interviewees were offered the option of a phone interview or a face-to-face interview.

**Data Analysis**

Our mixed method analysis began by a quantitative examination of existing institutional data we had gathered along with the data from the TEA. We calculated descriptive
After identifying descriptive trends, we identified participants for qualitative interviews to more robustly explain these patterns via interviews. The interview was recorded, transcribed, and coded independently by three researchers to identify themes through open coding. Interviewers took written notes during the interview, which were scanned and compared to the open coding to improve fidelity of analysis. Common themes were compared between all three researchers to ensure trustworthiness and dependability (Lincoln & Guba, 1985).

Results

Attrition Themes within the Quantitative Data

Institutional data was gathered for 97 science majors with secondary teaching minor or concentration who SFA has served since 2007. Of those students, 36 students were still enrolled as undergraduates at the university when the study began, meaning that most calculations focused on the 61 students who were no longer enrolled. Of those 61 students, 49 initially declared biology as a major while 12 began in chemistry. For context, over the same period there were 1,170 biology majors and 171 chemistry majors at the university, so these STEM teaching majors made up only 4.2% of the biology population and 7.0% of the chemistry major population before attrition.

Of the 61 science teaching majors, 22 students, or 36%, graduated in their science majors and certified to teach. Eighteen, or 30%, left the university without graduating. Ten students, or 16%, graduated in their initially declared major but did not complete the teacher certification coursework. Eleven students, or 18%, graduated in a different major than initially declared. We sought a pattern within the group that changed major, but found none. Two majors switched to interdisciplinary studies, while
one major each went to geology, accounting, creative writing, environmental science, mathematics, communication studies, finance, hospitality administration, and kinesiology.

Figure 1. Outcomes for aspiring science teaching majors by percentage

These persistence and attrition patterns are summarized in Figure 1. Roughly one third graduated prepared for science teaching, one third graduated but left the educator preparation program, and one third did not graduate. We then compared this pattern to the same populations for mathematics teaching majors at the university over the same period. Beginning with 164 mathematics teaching majors who are no longer at the university as undergraduates, 28% graduated in major and certified to teach, 31% graduated but left the educator preparation program, and 41% left without graduating.

We then examined the rate at which this same population of students actually taught in a Texas public school through data requested from the TEA. This analysis required removal of the 12 individuals who had discontinued (by graduation or otherwise) their university education within the last year, since these individuals have not yet had the opportunity to teach for a year. Of the remaining individuals (n=49),
18% of those who left the university without a degree taught in a Texas public school; 39% of those who graduated but did not certify taught in a Texas public school; and 80% of those who graduated certified taught in a Texas public school. These percentages are almost certainly lower than actual entry into the teaching profession since it does not include those who taught in private school, those who taught outside of Texas, or those who will go on to teach after this study is completed. However, since the measurement is the same across all three groups, teaching in a Texas public school is arguably a meaningful relative measure of entry into the teaching profession.

Table 1. Teaching outcomes of former science teaching majors by college outcome

<table>
<thead>
<tr>
<th>Status leaving SFA</th>
<th>Percentage who taught in Texas Public Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without a degree (completed degree elsewhere)</td>
<td>18%</td>
</tr>
<tr>
<td>Graduated but did not certify through SFA EPP</td>
<td>39%</td>
</tr>
<tr>
<td>Graduated in STEM with an SFA EPP cert</td>
<td>80%</td>
</tr>
</tbody>
</table>

Attrition as related to the T4 students

The analysis above neglects, however, to illuminate one important aspect of the persistence puzzle. Since 2012, 13 science teaching majors at SFA participated in the T4 program as a supplement to the EPP and received the additional supports from that program. Four of these students are still enrolled and the other 9 have all graduated in major and certified. Removing these 13 students from the general science teaching population makes the contrast more extreme. Figure 1 summarizes the attrition and persistence outcomes of both T4 and non-T4 students but disaggregating, we see a clearer picture in Table 2. While it appears from Figure 1 that the most common outcome for a science teaching major is to leave without graduation, Table 2 clarifies that this is only the most common outcome for non-T4 science teaching majors. For T4 science teaching majors, the only outcome is to graduate certified. This comparison of traditional certification pathway and the T4 certification pathway aligns with Wang and
Grimes (2000) theoretical framework which recommends validating outcomes assessment of retention endeavours, such as the T4 Noyce scholarship program.

Table 2. Comparison of academic outcomes for T4 and Non-T4 science students

<table>
<thead>
<tr>
<th></th>
<th>Graduated science, Certified in science</th>
<th>Graduated Science, No Cert</th>
<th>Graduated, Not in Major</th>
<th>Left Without Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-T4 Science Students</td>
<td>25%</td>
<td>19%</td>
<td>21%</td>
<td>35%</td>
</tr>
<tr>
<td>T4 Science Students</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Attrition Timing within the Quantitative Data**

Following the framework of Wang and Grimes (2000) that recommends determining dropout predictors, identifying critical points in the EPP, we examined the timing of attrition from either the EPP coursework or the science major coursework. During the traditional EPP, we examined attrition during the number of courses completed within the EPP. As Table 3 outlines, attrition is heaviest within the first two education courses. Of those who did not complete the program, 77% left before beginning the third course. For those that entered the third education course, the likelihood of completing the EPP course of study was 71%.

Table 3. EPP courses passed before leaving program or leaving university (n=42)

<table>
<thead>
<tr>
<th>EEP Courses</th>
<th>Number of students</th>
<th>Percentage of students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Application to EPP</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Application to Clinical Teaching</td>
<td>7</td>
<td>3</td>
</tr>
</tbody>
</table>
We applied the same method to identifying points of attrition during the science major coursework, we examined both the number of semesters students persisted in major before switching and the number of science courses students took before switching. We restricted our analysis to science teaching majors who switched major or left the university entirely. Over the course of our study, 29 individuals fit that category. Table 4 summarizes the number of semesters that a science major identified themselves as being the giving majors before switched major out of science or leaving the university. Notice that the median is only two semesters, and the mode is one semester. (For the sake of this analysis, the summer was interpreted as a semester if students were enrolled for at least one course.)

Table 4. Semesters in major before switching major or leaving university (n=29)

<table>
<thead>
<tr>
<th>Semesters</th>
<th>Number of student</th>
<th>Percentage of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>34%</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>28%</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>14%</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>14%</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>7%</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>3%</td>
</tr>
</tbody>
</table>

Similarly, in Table 5 we examine the number of courses successfully completed by science teaching majors who left their major field of study or left the university. Again, the median number of science courses is telling. This subpopulation successfully completed an average of just one science course, counting those inside or outside their major, before switching major or discontinuing at the university entirely.

Table 5. Science courses passed before switching major or leaving university (n=29)

<table>
<thead>
<tr>
<th>Science courses</th>
<th>Number of students</th>
<th>Percentage of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8</td>
<td>30%</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>33%</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>19%</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>7%</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>
Themes within the Qualitative Data

Several themes emerged from the interviews with science teaching majors across the persistence spectrum. The first theme was a skeptical view of EPP coursework. In five of the seven interviews, various types of skepticism emerged about the coursework. Two argued the EPP coursework was ‘overly general’ or ‘unfair’ because there were no specific resources provided for passing the science certification exams. Two others indicated the classes were ‘boring’ or ‘felt too easy,’ even as one of those interviewees praised their individual instructor. Another indicated that the extended time and monetary demands made certification in addition to the science major a suboptimal approach. All three researchers identified this theme. The EPP at the university did not offer a science teaching methods course, so students’ dissatisfaction with the curriculum of the EPP might be expected for students who are working to certify to teach science (Marder et al., 2018).

It appears plausible that STEM teaching majors, having gravitated toward highly quantifiable fields and having been enveloped in an educational environment where ‘what is tested’ is deemed most important, did not attach high value to the EPP training with its focus on sociological or psychological course content such as ‘culturally responsive pedagogy,’ ‘sociocultural and historic perspectives,’ etc. This viewpoint is common for pre-service teachers who never experienced STEM classes that utilized culturally responsive pedagogy or practical and sociocultural application to course content (Koch, Carrier, & Walkowiak, 2017). It is easy to understand how these students might reasonably ask if there actually exists a quantifiable benefit to traditional
undergraduate certification as opposed to certification by another means. We will address this concern later in our discussion.

A second related theme emerged among the interviewees: students who left teacher preparation had limited mentorship or role models in the teaching profession. Not a single participant who left the STEM teaching career path indicated that anyone had been concerned to see them go. The closest was one student who indicated that her parents had originally liked the idea of a career in teaching because ‘they wanted me to stay close to home.’ On the contrary, most interviewees who left teaching experienced only attitudes of indifference about teaching and most who left biology or chemistry experienced no encouragement to stay from faculty, family, or friends. One interviewee even recalled a faculty member saying to her, ‘I’m sorry you’re not competent to get through courses.’ That student did persist in course work, but in a different major.

In all five interviews with students who left the EPP, no STEM teacher had established an ongoing relationship with the student. Several mentioned positive experiences and interactions with STEM and education faculty members, one saying they were ‘very supportive’. One mentioned being discouraged by the fact that after years of being a STEM major, faculty in her major discipline still did not know her name. Only one participant described an instance where a faculty had encouraged them to teach.

In contrast, both interviewees with participants who persisted to teaching mentioned professional mentors and also faculty encouragement to teach. These students mentioned being a part of Talented Teachers in Training for Texas (T4) in describing their positive influences. It is noteworthy that one of these two participants mentioned a faculty member telling her, ‘You have so much potential to do something
else [besides teach].’ But it appears for this student that the positive influences toward teaching had a greater impact than the advice to pursue a different career.

This brings us to a third related theme: *students’ decision to persist often hinged on one person’s input or influence from individuals with limited knowledge of STEM careers or teaching.* One student who switched to nursing indicated that college friends in the nursing program were the primary influence to switch majors. These individuals were peers who had never experienced the nursing profession or any other. Another individual switched to health sciences because her roommate and best friend had that major. Another was encouraged to pursue teaching by her mother because ‘teaching is a better job for a mom.’ Although she did not certify as an undergraduate, she did go on to teach for three years. Multiple students described great uncertainty and repeated changes in direction surrounding their major course of study. It appears that in the absence of clear, objectively knowledgeable experience or direction, students are open to whatever major directions their social circle has to offer.

Although perhaps not a theme, we include this cautionary note: one interviewee was classified by our quantitative research as ‘discontinued without completing degree,’ when in fact she was taking a semester to attend to a family situation. The semester after the quantitative data was gathered, she did in fact return to the university and successfully completed a clinical teaching semester in science. This student, who is Hispanic and female, a part of two underrepresented groups in STEM, serves as a reminder that our traditional timelines and assumptions about continuous progress toward degree may misunderstand and ill support underrepresented student populations.

**Discussion and Implications**

**Student Implications**
Our research findings indicate that aspiring science teachers are at a high risk of attrition from the beginning of their undergraduate experience. Numerically, science teaching majors outside the T4 program were only one fourth as likely to persist to a science degree and a teaching certification. These results appear quite similar to the results of aspiring mathematics teachers as well, so there is every indication that the concern is broader than just science teaching.

The timing of student attrition indicates that most students who leave the sciences do so in the first year and after only completing an average of one science course. Students who leave the EPP typically leave within the first two courses. Based upon these pinpointed times within the undergraduate experience, intervention needs to be quick and likely initiated based off of a student’s declaration of a science teaching major rather than passively off of a student’s getting to a particular point such as a course, EPP admission, or classification designed to engage or support science teaching majors. Hence, we observe specific attrition points in line with Wang and Grimes’ (2000) general attrition framework.

Our data also indicates to the idea that students who leave the EPP do not appreciate the intrinsic value of the formal teacher preparation and to not see the extrinsic value of formal teacher preparation, especially when it is removed from the content area that the student is interested in teaching. This aligns with the findings of Marder et al. (2018) whose research findings indicated that STEM majors were more interested in teacher preparation programs that were specifically geared to their major and teaching area. Any intervention aligned with the concerns above might address these issues as well.

**Program Implications**
From the interview data it seems clear that beginning students are often quite impressionable in their choice of career and major. Within the university EPP in our study, there is a dearth of influence from practicing science teachers or those who highly value the profession, at least outside of the T4 program. One clear implication is that programs seeking to address attrition should proactively connect with students who declare an intent to pursue science teaching rather than reactively wait for students to take a certain course, reach a certain level, or connect to community themselves. It would appear that a fruitful goal for systematic program efforts should include connecting students with a declared intent to teach science with individuals who value and are knowledgeable about both the sciences and the teaching profession. It seems that peers often have an outsized influence on career path as well, so facilitating this type of engagement in a venue where science teaching majors could connect with other science teaching majors would potentially have a compounding effect. Again, there seems to be a brief timeframe in which to pursue this engagement.

Proactive and early intervention is exactly the type of engagement described by those within the T4 program. The program connects aspiring STEM teaching majors outside the classroom with STEM teachers, administrators, and those who highly value the teaching profession. Further, programs events connect aspiring STEM teachers to others with the same declared interest, lending their aspirations legitimacy and creating a peer mentoring ethos. The program evidenced a 100% rate of science graduation and certification, which is four times the success rate of science majors seeking certification outside the program.

Specific actionable implications, modelled off of the T4 program, might include:
actively contacting science teaching candidates in their first semester in major welcoming them and making them aware of activities available to science teaching candidates;

providing social events early in the semester targeting new science teacher candidates to build community with experienced science teacher candidates, mentors, etc.;

offering opportunities to experience real classrooms early in their course of study without long-term commitment (for some students even commitment to a 16-week course may be too high a threshold);

bringing new science teachers, veteran science teachers, and principals to campus to interact with prospective teachers;

providing short professional development sessions for science teachers that explicitly include aspiring science teachers;

providing intrusive advisors who meet with science teacher candidates multiple times a semester, communicate the value of science teaching, ask specific questions about student success, and have the time to assist both in planning coursework and cultivating students’ professional identity;

having advisors, science faculty, and education faculty meet to discuss specific students’ progress and risks (we do this at mid-semester); and

discussing context specific ways to provide science teaching majors the time and relationships formulate self-identity as science teachers.

**Additional Discussion**

One theme identified in the interviews that bears addressing was skepticism over whether traditional undergraduate teacher certification yielded any quantifiable value for science teaching majors. Although it might be argued that students should be
concerned about more than ‘quantifiable value,’ the question of quantifiable value should be addressed. Utilizing Texas Education Agency data on Texas public schools in parallel with university records, over the past decade only 1% of those entering the university as a STEM major certified to teach as an undergraduate. In contrast, 10% of those same students ended up teaching in a Texas public school. Which teachers persisted in their career? Restricting our attention to STEM majors who enrolled Fall 2007 or after, then graduated or discontinued Summer 2012 or before, we examined five-year retention in a Texas public classroom. For those who did not earn an undergraduate certification, the five-year retention was 37%. Of those who earned undergraduate certification, the five-year retention was 88%. (We note again that this data only considers public school teaching in Texas as proxy for actual teaching and retention rates. Also, we use the term ‘five-year retention rate’ to denote the percentage of those who taught at least one year in a public school that taught at least five years in a public school.)

Clearly, a vast quantifiable distinction exists between retention rates of teachers who chose a traditional undergraduate teacher certification and those who chose an alternative certification. This fits with the research of Ingersoll et al. (2012), Redding and Smith (2016), and Zhang and Zeller (2016) whose findings indicate that traditionally certified STEM teachers stay in the teaching fields longer than those from alternative certification programs. However, the fact that students seemed uninformed about the benefit of the program in terms of longevity in the profession speaks to a programmatic consideration. It appears there are no systematic mechanisms in place to communicate the value of traditional certification to science teaching majors (or any other majors). This evidence appears highly relevant to students’ best interest and career prospects. Programs must work to clearly communicate the tangible value in terms of
teacher retention that comes from their program. When considered in light of the relatively small number of education courses taken by those who left teacher certification, the urgency of addressing this issue as soon as a student self-identifies as intending to teach seems critical. The information is exceedingly relevant to students and most institutions have such data or could get it for their specific student population.

Our results are similar to the findings of Marder et al. (2018) in suggesting that STEM majors might be more interested in teaching if they received more information and additional support regarding STEM teaching. In their work they found that students will ill-informed about the salary levels of STEM teachers and would have been substantially more interested in the career possibility if they had access to more accurate and readily accessible information about STEM teaching as a career.

Conclusion

The short time horizon during which science teaching majors who leave are ‘available’ places tremendous onus on institutions of higher education to proactively seek avenues to support and engage these students in a timely manner. The attrition rates are so high and the number of classes during typical student is engaged before leaving is so low, that it might be most accurate to characterize every science teaching major as “at risk” immediately upon declaring that major. If we are to improve science teacher attrition rates, it is critical that programs must proactively engage these students with an eye toward the timing and the engagements that might serve them best. Our results correlate to Hong et al. (2018) in suggesting that peer groups, family, and faculty are vital to the decision-making process of pre-service teachers as they choose to persist or drop out of EPPs. But given that universities do not control family and that in-class faculty connections often appear too late an intervention, we need to develop comprehensive ways to connect students for faculty and mentors, along with providing potential
connections to peer groups in science teaching that will best support science teaching majors’ stated career aspirations. Programs must critically examine the timing of attrition points and peer social interactions with humble candour, and address existing structures that fail to serve students in their time of most need for engagement. Change at the university level must include specific evidence-based interventions and a systemic and institutionally funded support pathway including mentoring, peer connections, experiential learning, and interaction with practitioners in the field.

**Limitations and Future Research**

A variety of issues limited both the quantitative and qualitative portions of this study. In regard to the quantitative portion of the study, relatively small number of aspiring science teaching majors made disaggregating the population difficult. This limitation also affected our examination of which students actually entered the classroom as teachers. In order the keep sample size sufficiently large, we examined those who students had left the institution, by graduation or discontinuance, from Fall 2007 to Summer 2017. However, this only left one academic year for these individuals to teach. Were the population larger, it would have been preferable to provide more years of opportunity to choose teaching.

Perhaps even more concerning, all students examined were from the same regional comprehensive university. Further work is needed to examine the extent to which scepticism of EPP coursework, the lack of science teaching mentorship, and the arguably undue influence uniformed opinions about science teaching are phenomena that exhibit similarly in other contexts.

In regard to the qualitative process itself, the primary limitation is that of all case studies – one is tempted to generalize from a very small group onto an entire population. However, generalizability is not the primary goal of qualitative research
(Maxwell, 1992). These themes might well be examined in further work across much larger populations by survey rather than interview.

Finally, although the interviews were intended to be open ended, the nature of the interview questions may have encouraged students to attribute their academic persistence or change to interpersonal factors rather than to course work, financial factors, or something else entirely unanticipated. Our research was designed to guide science and EPP educators toward potential factors of persistence or attrition that might be examined within their own context.

References


**Appendix - Interview Protocol**

0. First, thank you for taking the time to do this interview. I just wanted to confirm that you received the informed consent via email and that you agree to let us use your answers anonymously.

1. Initially you registered as a science major planning to certify to teach, but then you changed course. When did you first decide to pursue a different path?

2. What influenced that change in direction?

3. Were there any obstacles or barriers to certifying in science teaching that contributed to that decision?

4. How did peers or family influence your career choice, both initially and as it changed?

5. How did faculty or professional mentors affect that change?

6. Looking back, do you have any regrets about your major and career choices? Explain.

7. Are you or would you consider teaching in the future? Why or why not?
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