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Profiles of U.S. science teacher candidates: Safeguards amidst the gathering storm

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The shortage of science teachers in the United States and throughout the world indicates a collective need to recruit more students into the science teaching field and to retain current science teachers. This study explores the profiles of U.S. science teacher candidates and investigates what attracts and discourages these pre-service teachers into teaching science. Through the use of survey and structured interview approaches we investigated the profiles of pre-service elementary, middle school, and high school teachers (n = 109) who were interested in teaching science. Common findings among this set of science teacher candidates included: positive science experiences with K-12 teachers during childhood, beliefs that certain teacher preparation content courses were roadblocks to becoming certified, unfamiliarity with the employment market for science teachers, and a lack of being recruited to teach science. Based on these profile characteristics of science teacher candidates, teacher educators may pursue specific strategies to encourage more teacher-candidates to select science as their teaching field.

Keywords: pre-service, science teacher-candidates, profiles, recruitment

Introduction

There is a concern in the United States about science teacher shortages. U.S. President Obama recently stated, "*...year after year the gap between the number of teachers we have and the number of teachers we need in these areas [math, science, technology and engineering] is widening. The shortfall is projected to climb past a quarter of a million teachers in the next five years -- and that gap is most pronounced in predominately poor and minority schools."* (Obama, January 2010). An action plan by the U.S. National Academies of Science [NAS], titled *Rising above the Gathering Storm*, highlights the urgency to recruit more science and mathematics teachers in the United States, optimally 10,000 each year to improve science and science education in the United States (NAS, 2007). The NAS goal is clear: *"Annually recruit 10,000 science and mathematics teachers... thereby educating 10 million minds. Attract 10,000 of America's brightest students to the teaching profession every year, each of whom can have an impact on 1,000 students over the course of their careers* (NAS, 2007, p.5)." It is hoped by many in the U.S. that this directive will help combat the predicted "*gathering storm*" of reduced economic prosperity and declining student performance in science in the United States in future years.

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The graduation of more students who are certified to teach science, thereby helping to meet the goal of *10,000 science teachers* each year, is a top priority at our university and at many throughout the United States due to a nation-wide shortage of science teachers. The latest nationwide Teacher Shortage List (TSA) for the 2010-2011 school years lists science as one of the teaching shortage areas in 48 states in the United States (U.S. Department of Education, 2011). A shortage of science teachers is also occurring in other developed countries in Europe such as England (Osborne & Dillion, 2008), Australia (Angove, 2010), and in Zambia, Tanzania, and other African countries (Malakata, 2009). Throughout the world, there is a projected worldwide shortage of 18 million teachers of all subjects over the next decade, most critically in Sub-Saharan Africa and the Arab States (United Nations, 2006). As we initiate pre-service science teacher recruiting efforts at our university including posting video clips that promote teaching in science, presenting teacher shortage information to incoming teacher candidates, and organizing a National Science Teacher Association [NSTA] student chapter, we wonder "who wants to become a science teacher?". In other words, are there common characteristics or profiles of college students who are interested in teaching science? By uncovering common characteristics, we may be able attract and retain more candidates in our science teacher preparation programs.

Purpose

The purpose of this study is to determine common characteristics or profiles of university students interested in becoming science teachers at the elementary and secondary school levels.

Background

During the last half of the twentieth century, the United States was a leader in science and technology (NAS, 2007). Significant investment in research and education has contributed in the U. S. to critical benefits including security, healthcare, economic competitiveness, and the creation of jobs. However, the NAS warns that U. S. leadership is now being challenged: "*Several nations have faster growing economies, and they are investing an increasing percentage of their resources in science and technology" (*NAS, 2007, p. 204). To be one of the world leaders in science, the United States needs more teachers who are knowledgeable in science.

The U. S. national shortage of qualified science teachers is clearly illustrated by the national TSA and also by the practice of "out-of-field" science teaching which unfortunately has persisted over many years. Out-of-field teaching occurs when teachers without an undergraduate major or certification in the field are teaching science, typically in high school or middle school. Ten years ago, during the 1999-2000 school year, a comprehensive national study of out-of-field teaching in science was conducted at both the middle and high school grade levels. Shockingly, out-of-field physical science teachers taught 93% of middle school students. At the high school level, 45% of biology students, 61% of chemistry students, and 67% of physics students were taught by out-of-field teachers (NAS, 2007). The situation has not improved over the past decade. Today, many school districts have difficulty finding highly qualified science teachers, especially in chemistry and physics (Bureau of Labor Statistics, 2010). The problem is particularly discouraging in states with rapidly growing populations such as in our state, Texas, where during the 2008 school academic year 26% of science teachers in high-poverty schools (schools with more than 75% students in poverty) were not fully certified in their subject field and 34% were considered "out-of-field" (Fuller, 2009). Fuller (2009) reports that the shortage of science teachers has

increased by over 80% since 2004 and will continue to increase due to enrollment demands and because of Texas' new 4x4 science requirement that high school students must take four years of science. In Texas, the prevalence of alternative certification programs also contributes to the shortage of science teachers. More science teachers are now being prepared in alternative certification programs than in traditional university programs. Teachers certified in alternative training programs have higher attrition rates after 5 years than those certified in traditional programs (Fuller, 2009). There is a high need for science teachers in Texas and throughout the United States. As stated above, 48 states indicated science as a teaching shortage area for the 2010-11 school year (U.S. Department of Education, 2011). On a national level, future growth in employment for secondary teachers is projected between 7 to 13% with job prospects best for teachers in high-demand fields such as science (Bureau of Labor Statistics, 2010).

The shortage of science teachers in the U. S. combined with the widespread practice of out-of-field teaching in the past may be a contributing factor to the lack of improvement of U. S. students' performance on national and international science achievement assessments. Recent National Assessment of Educational Progress [NAEP] science academic achievement reports indicate little progress in science scores that indicate mastery of science concepts (National Center for Education Statistics, 2010). A new NAEP science framework was introduced in 2009. Although the NAEP 2009 Science test scores cannot be compared to earlier NAEP science scores, proficiency levels on the new science frameworks at 4^{th}, 8^{th} and 12^{th} grade levels indicate little to no improvement in mastery of science concepts. Only thirty-four percent of 4^{th} graders, thirty percent of 8^{th} graders and twenty-one percent of 12^{th} graders performed at proficiency levels that represent a mastery of understanding of science knowledge and skills. The majority of students at all grade levels performed at basic levels that demonstrate only partial mastery of the science knowledge and skills (National Center for Education Statistics, 2010). In previous years, NAEP 8^{th} grade science scores showed no overall improvement in the proficient level from 1996 to 2005 with only 29% reaching the proficiency level. At the 12^{th} grade level, there was a drop in average NAEP science scores between 1996 and 2005 with declines in the percentages of students in "at or above basic" and "at or above proficient" categories (National Center for Education Statistics, 2007). The academic performance of U. S. students who performed at the advanced levels in the 4^{th} and 8^{th} grades on the Third International Comparative Mathematics and Science Study (TIMSS) is also discouraging. Students' scores in 2007 declined from 1995 (National Research Council, 2010).

The shortage of qualified science and math teachers is not a new phenomenon in the United States. According to Weiss (2007), we have struggled with shortages since the 1940s. A commonly held belief today is that shortages are due to the low production of new science teachers coupled with the retirement of existing science teachers. Ingersoll and Perda (2009) conclude in their comprehensive report based upon a National Center for Education Statistics database that the current supply of new science teachers can cover retirement losses to the teaching profession but *cannot* currently cover "pre-retirement losses" of teachers. This is a critical issue because science teachers are more likely than teachers of other subjects to leave the teaching profession early, and thus, contribute to shortages (Guarino, Santibanez, & Daley, 2006). These pre-retirement losses are due primarily to job dissatisfaction, discontent with working conditions, and better career options elsewhere (Ingersoll & Perda, 2009; Ingersoll, 2001). To illustrate, in the academic year 2000, (Ingersoll & Perda, 2009) approximately 35,000 mathematics and science teachers left teaching including 8,000 due to retirement and 18,000 due to job dissatisfaction. Clearly, increasing the supply of new science teachers will reduce the teaching shortage only if these teachers are retained in the profession. Ingersoll & Perda (2009) indicated*"…schools with more support for new teachers, more generous salary schedules, fewer*

student discipline problems, more adequate resources and classroom supplies, more effective leadership and enhanced faculty input into school decision-making—all have significantly lower levels of teacher turnover (Ingersoll & Perda, 2009, p. 38)

The characteristics of teacher candidates are varied but there are some common characteristics. For example, teacher candidates in the United States are predominantly white and female (NRC, 2010; Guarino et al., 2006). Also, some studies indicate that students enter the teaching profession for altruistic reasons to serve society (Guarino et al. 2006). Weiss (2007) determined, based upon his interviews of 25 pre-service science teachers, that science pre-service teachers had higher SAT scores and higher school GPAs in comparison to the general population of college entrants. Weiss also found that three-fourths of his sample had been athletes and one-third active in clubs. Furthermore, 96% of them had experiences with children such as tutoring, coaching, substitute teaching, and internships. Other commonalities were the similarity in the career paths of the fathers of the students. Approximately 40% of the students had a father who had a career either in science research, engineering or medicine. Nearly one-third of the students had parents who were in the education field and 48% had a relative in education. Their motivation to consider science teaching was their "love of science" with 96% mentioning it in their interviews. Three-fourths of the students reported a favorite science teacher who had influenced them to consider science teaching (Weiss, 2007). Weiss's (2007) study appears to be unique in determining common characteristics in pre-service secondary teachers. Furthermore, a review of the literature revealed a paucity of data detailing the characteristics of teacher candidates across the elementary, middle school, and high school levels who want to teach science in the United States.

Research Questions

In this study we are investigating the profiles of elementary, middle school, and high school teacher candidates with high interests in teaching science. Our research questions include:

1) What influences teacher candidates to select science as their teaching field?
2) What are their preferences for teaching different age students and different content areas?
3) What is the profile of pre-service teachers who are interested in teaching science?

An understanding of pre-service science teacher profiles may assist us and other teacher educators in attracting more teacher candidates to science teacher preparation programs.

Methodology

Participants

The participants were elementary (n = 49), middle school (n = 39), and high school (n = 21) pre-service teachers enrolled in teacher preparation courses at a large university who volunteered to take a survey about teaching preferences. Our survey sample of elementary participants was drawn from those with high interest (M=4.0 or above) in teaching science as indicated by their answers on the questionnaire. In a similar manner middle and high school participants were drawn from courses in science teaching certification programs. Two-thirds of the pre-service teachers were Anglo and the remaining one-third was either African-American, or Hispanic. Three-fourths of these teachers were female. We used questionnaire (see Appendix) and structured interview approaches to investigate pre-service teachers' preferences for teaching science,

other content areas, and particular grade levels. In addition we queried their appreciation of science, their prior experiences with students, and whether they were recruited into teaching.

Instrumentation

The survey instrument presented 23 Likert-like items (see Appendix) including prompts such as "I have an interest in teaching in the Middle Grades (or High School Grades) because I like teaching at this content level" and "I am interested in teaching in Middle School (or High School) because I perceive a favorable employment market." The instrument also contained four open-ended questions including "Please explain in your own words why you want to teach in High School (or Middle School)" and "Please explain any characteristics of Middle School students (or High School students) that cause you to *not want to* teach at the Middle School (or High School) level." The questionnaire was based upon an eighteen-item survey that was used to determine what attracted pre-service teachers to the middle grades (Radcliffe & Mandeville, 2007). The structured interviews included 5 open-ended questions that explored participants' perceptions about teaching science with prompts such as "What people have influenced you to teach science?" and "What experiences have influenced you to teach science?"

Procedures

The questionnaires were distributed to pre-service teachers on a voluntary and anonymous basis by their professors during the teacher preparation classes in the 2008/09 fall and spring semesters. One hundred and five pre-service teachers returned useable surveys yielding a response rate of 100%. Students (n = 14, elementary; n = 9, middle school; n = 7 high school) were randomly selected from this population and asked on a voluntary basis to participate in a structured interview that was conducted after the class period by the college professor.

The responses to the Likert-like questions on the questionnaire were analyzed using a SPSS computer software program. Three science education faculty members independently analyzed the answers to the four open-ended questions on the questionnaires through a coding process that identified keywords or recurring concepts in the answers. This coding process followed qualitative research protocols by "looking for recurring regularities in the data" (Patton, 1990, p. 403). Each of the three faculty members independently read all responses. Statements from the responses that represented similar ideas, or that contained similar key phrases or terms, were grouped together under one code. To establish inter-rater reliability the codes from each of the faculty members were then compared and discussed by the faculty members to determine their relatedness. Similar codes were retained. We also interviewed 28% of the students in the study to help us confirm consistency in findings throughout the study. The responses to the interview questions, which had been recorded using a digital voice recorder and with the interviewee's written permission, were coded by two science education faculty based on the coding process previously described. Faculty members then compared their coding to determine their relatedness and similar codes were retained. The results were analyzed and categorized by the pre-service teachers' intended teaching levels (elementary, middle grades, or high school).

Results

Elementary Grades Science-Oriented Pre-Service Teachers

We surveyed 49 *science-oriented* elementary pre-service teachers to determine their profiles or common characteristics. As shown in Table I [Response Mean Scores and Standard Deviations

for Preferences among Elementary, Middle School, and High School Pre-service Teachers], their preference to teach science was strong (*M* = 4.51). They consistently demonstrated only moderate interest in other content areas (not shown on table) including English (*M* = 3.76), social studies (*M* = 3.71), math (*M* = 3.60), and other subjects (*M* = 3.72). They indicated a strong interest to teach elementary age students (*M* = 4.82) and to teach at the elementary content level (*M* = 4.41). We found through their survey responses that they most favored teaching the second grade (*M* = 4.19), with declining interest as the grade levels increased. Other reported profile information in the survey that may be relevant to understanding and attracting elementary teachers to teach science includes these respondents' noteworthy extent of prior positive experiences (*M* = 4.10) with their own elementary teachers that may have attracted them to younger students. Also, having prior experiences with elementary age students was relatively strong (*M* = 3.81). As a group the pre-service elementary teachers seemed unaffected by the employment market outlook for their level (*M* = 2.82).

We interviewed 14 pre-service elementary teachers about their thoughts on teaching science. Interview data revealed two influential factors that caused pre-service teachers to consider science teaching including having "good science teachers" and doing interesting science experiments during their K-12 years. Repeatedly, they mentioned the influence of a good science teacher, recalling a first grade teacher, a principal in fifth grade, or a high school teacher, including a specific biology teacher. Additional interview prompts that investigated what else influenced the elementary pre-service to consider teaching science revealed personal background factors including interesting family vacations, a love for animals, and growing up in the country. The interviewees also cited specific positive experiences in science classes including science labs and discussing scientific questions.

Table I. Response Mean Scores and Standard Deviations for Preferences among Elementary,Middle School, and High School Pre-service Teachers

	Groups		
Preference	Elementary Tchr. Mean (S.D.)	Middle grade Tchr. Mean (S.D.)	High school Tchr. Mean (S.D.)
Prefer 'my' age group	4.82 (.49)	4.71 (.52)	4.59 (.72)
Prefer 'my' content level	4.41 (1.02)	4.70 (.68)	4.76 (.44)
Prefer to teach science	4.51 (.51)	4.71 (.46)	4.65 (.49)
See 'my' employment market as favorable	2.82 (1.32)	3.94 (1.03)	3.35 (1.12)
Have prior experience with 'my' level students	3.81 (1.44)	3.17 (1.71)	3.35 (1.84)
Positive experiences at my' level attracted me	4.10 (1.15)	3.51 (1.42)	4.06 (1.20)
Recruited to teach at 'my' level	2.27 (1.47)	1.80 (1.16)	2.00 (1.23)

NOTE: *n* = 105. Score range was 1 to 5. "Agree to a great extent" = 5, "Agree to a modest extent" = 4, "Agree to a small extent" = 3, "Neither agree or disagree" = 2, and "Disagree" =1

Table II. Reasons Elementary Respondents Favor 'My Level' and are Averse to Middle Grades

Why elementary respondents favor the elementary grades	Why elementary respondents are averse to the middle grades
1. Like students' ages	1. Students' attitudes are a problem
2. Like students' motivation levels	2. Too many disciplinary issues
3. I can influence these students	3. Dislike teaching only one subject all day
4. Favor content level	4. Courses to get middle grades degree are difficult
5. I am able to teach at this level	5. Dislike constancy of state mandated testing

NOTES: n = 49. Reasons are based on responses to open-ended questions on a survey.
Why elementary respondents are averse to high school grades was not addressed in this survey.

We also investigated through survey and interviews whether the elementary school participants were averse to teaching at the middle school level. In response to the open-ended questions on the surveys, the respondents' favor for teaching the elementary grades and critical aversions to the middle grades are summarized in Table II [Reasons Elementary Respondents Favor 'My Level' and are Averse to Middle Grades]. The respondents' survey mean score for the prompt "How do you feel about teaching the middle school age level" was low (M = 2.49), and their preferences by grade were very low: fifth grade (M = 2.40), sixth grade (M = 2.10), seventh grade (M = 2.02), and eighth grade (M = 1.98). The interviews with some of the participants uncovered their explanations for preferring the elementary grades including "enjoying the younger kids", "have a natural feeling for the younger", and "prefer to teach all subjects". The strength of these preferences seemed modest in comparison to their strong aversions to the middle grade students that often included "I do not like their attitude", with elaboration about the students being "rebellious", "mouthy and moody", and having negative attitudes.

Middle Grades Pre-Service Science Teachers

We surveyed 39 pre-service middle school science teachers (grades 4-8) to determine common characteristics or profiles. We determined through their survey responses, as reported in Table I, that they most favored teaching in the sixth and seventh grades (M = 4.29 and M = 3.91), with declining interest for eighth (M = 3.51), fifth (M = 3.48), and fourth (M = 3.26) grades. Compared to the respondents' strong preference for teaching science (M = 4.71), they demonstrated steadily declining interest in other content areas including math (M = 3.46), social studies (M = 3.00), other subjects (M = 2.59), and English (M = 2.40). Other surveyed profile information that may be relevant to understanding and attracting middle grades teachers to teach science includes these respondents' positive prior experiences during their middle school years (M = 3.51), relatively weak prior experiences with middle grades students (M = 3.17), their lack of being recruited to teaching (M = 1.80), and their positive perceptions about the favorable employment market for middle school teachers (M = 3.94).

We investigated through open-ended survey questions how middle school pre-service teachers felt about teaching at their level compared to teaching at other levels. As reported in Table III [Reasons Middle Grade Respondents Favor 'My Level and are Averse to Other Levels,] several factors dampen their interest for high school teaching including the higher level of content, concerns about being able to relate to and influence high school students, and the narrow age

Table III. Reasons Middle Grade Respondents Favor 'My Level" and are Averse to Other Levels

Why middle grade respondents favor the middle grades	Why they are averse to elementary grades	Why they are averse to high school grades
1. Can influence students	1. Students are too young	1. Students are too near my age
2. Prefer students' age	2. Too many content areas	2. Curriculum is "too high"
3. Like content level	3. It's like babysitting	3. Cannot influence students
4. Can relate to students	4. Content is "too low"	4. Don't like students' attitudes
5. Interested in students' developmental issues	5. Students cannot think at higher levels	5. My professional ability as a teacher does not match H. S.

Note: $n = 39$.

gap between these young teachers and high school students. Many of the middle school respondents indicated that after several years of teaching at the middle school level they might want to teach high school. However, the respondents were very averse to teaching in the elementary grades due primarily to the age of students and the curriculum.

Our interviews with 9 middle school pre-service teachers focused on who and what may have influenced them to teach science. They identified a range of influential persons including teachers from fifth grade, high school, college, and "my Mom". They cited positive experiences in high school science, college chemistry, elementary school science, and working as a teacher's aide during science class as factors that influenced them to teach science. During the interviews they also explained that K-3 students are too young, the school setting is similar to babysitting, and the level of content is too elementary.

High School Pre-Service Science Teachers

Profile information for the 17 high school pre-service teachers that we surveyed is reported in Table I. This group had stronger preferences for their content level, but lesser preferences for their age group in comparison to elementary and middle school pre-service teachers. Specifically, the respondents reported strong preference for teaching science ($M = 4.65$) as well as math ($M = 3.41$) and other subjects ($M = 3.88$) that most often included sports and coaching. They demonstrated less interest in the humanities including social studies ($M = 1.76$) and English ($M = 1.24$). Survey responses indicated that the respondents most favored teaching the eleventh and twelfth grades ($M = 4.82$ and $M = 4.71$), with declining interest for tenth ($M = 4.53$), ninth ($M = 4.00$), and eighth ($M = 3.35$) grades. Interestingly, one of the key influences (M=4.06), for these respondents' decisions to teach science are their positive science experiences during their high school years. Survey results also revealed that prior experiences with high school age students, being recruited to teach science, and perspective on the employment market, appear to be weak factors in shaping pre-service high school teachers' decisions to choose science teaching.

We interviewed seven high school pre-service teachers to determine why they chose to be a science teacher, why they chose the high school level, and what influenced them in this direction. Most interviewees indicated that they liked science or learning, and two explained that they liked working with children. Two interviewees stated that having an “amazing” or “motivating” science teacher who did “hands-on” activities influenced their decision to become science teachers. As one said, “My high school biology teacher was amazing. We did a lot of ‘hands-on’. That is

when I started getting interested in science because I was able to apply it to a lot of things. It made it fun and interesting". A respondent explained that tutoring high school students caused her to consider high school science teaching. Another influence was their strong belief that "hands-on" science teaching or inquiry science made science more interesting and developed critical thinking skills. Some interviewees described reasons they chose to teach science at the high school level including they could teach a specific discipline and the students were more mature, at higher cognitive levels, and more challenging to teach. One indicated that she would love to teach at the elementary school level as well. She felt she owed it to society to take her time and talent to inspire future generations.

Due to our concern about science teacher shortages in both middle schools and high schools, we investigated reasons that the high school participants were attracted to the high school level and were averse to teaching at the middle school level. The respondents' preference for teaching the highest grades and aversions to the middle grades are summarized in Table IV [Reasons High School Respondents Favor 'My Level' and are Averse to Middle Grades]. Clearly, high school students' capacity for higher-level thought and their subsequent readiness for a higher level of content attracts high school pre-service teachers. In addition, they feel high school students' level of maturity and focus on graduation and careers differentiates them from middle school students. They appear to shun middle school students due to issues related to maturity such as hormones, puberty issues and classroom management issues. However, they were not as sharply critical of middle school students as were the elementary level pre-service teachers who often complained about middle school students' attitudes. Consistent with these findings, the high school respondents' survey mean score for the survey prompt "how do you feel about teaching the middle school age level" was low (M = 2.94) as was their preference for the middle school content level (M = 2.88).

Discussion

Our findings regarding the profiles of future science teachers support the profile features that Weiss (2007) described based on his interviews of future secondary science teachers. Findings from our surveys and interviews were consistent with Weiss's study; we found that "good science teachers" or school experiences influence pre-service elementary and high school science teachers at the elementary and high school levels in their decisions to become science teachers. Also consistent with Weiss's study, but to a lesser degree, was the reporting of prior experiences with school age students. Elementary pre-service teachers were more likely to report having prior experiences with "my level" students (M = 3.81) than middle (M = 3.17) or high school (M = 3.35) pre-service teachers. Our study expanded on Weiss's work because our sample population

Table IV. Reasons High School Respondents Favor 'My Level' and are Averse to Middle Grades

Why high school respondents favor the high school grades	Why high school respondents are averse to the middle grades
1. Students capable of higher level thought	1. Maturity level (immature students)
2. Students at high content level	2. Classroom management problems
3. Higher level of students' maturity	3. Content level understanding is too low
4. Easy to motivate, influence & teach	4. Age levels (too young)
5. Students focus on graduation & careers	5. Hormones and puberty issues

NOTES: n = 21.

included elementary pre-service teachers with a strong interest in science. The following discussion, which focuses on the three levels of pre-service teachers, explores the profiles of these prospective teachers in relation to opportunities for recruiting more candidates to teach science.

Elementary Grades Science-Oriented Pre-Service Teachers

Pre-service elementary teachers explained that 'good science' teachers in their past have influenced their interest in teaching science. Clearly this presents a recruiting avenue, although long term, for attracting potential teachers to science. In other words, an effective way to build the ranks of science teachers is to do a good job teaching them science, starting at a young age. This group had strong preferences for teaching younger students and major aversions to working with older students. They favored teaching second grade with declining interests in the upper elementary grades. Consequently, it seems unlikely that educators could recruit successfully from elementary level teachers for middle school or high school science teacher shortages. Many pre-service elementary teachers reported having positive experiences when they were a student at their favored 'age' group. This presents a question: what were their experiences as students at other age levels? Possibly, providing these pre-service teachers with positive experiences working with older students might open some minds for recruiting them into the higher-need levels in the middle grades or high school. However, elementary teachers seem averse to the content level preparation for older ages. This presents other questions: what are their specific aversions, and how might they be mitigated? Interestingly, none of the pre-service elementary teachers in our sample experienced recruitment into teaching science. Furthermore, as a group, they seemed unaware of the relatively poor employment market for their grade levels in comparison to a much more attractive market for the upper grades. Considering both of these factors, there may be opportunities to recruit from the elementary teacher ranks early in their teacher preparation program.

Middle Grades Pre-Service Science Teachers

Consistent with our findings about elementary pre-service teachers and the importance of favorable experiences in science classes during childhood, "good science teachers" in the past influenced pre-service middle school teachers to choose science teaching in the middle grades. These pre-service teachers had positive experiences when they were a student in their favored 'age' group. This presents questions that may guide recruiting science teachers for the middle grades. What types of positive experiences have they had and how might these influence their choice for the middle grades? Also, in line with findings about elementary pre-service teachers, middle school teachers are rarely recruited into teaching. None indicated they experienced recruitment into teaching science; consequently recruiting may be an effective strategy for building the ranks of middle grades science teachers.

Middle grades teachers frequently admitted an interest in teaching high school after they have gained experience in the middle grades. Clearly there is potential for recruiting from the middle school level to the high school level for science teachers. Ironically, middle grades pre-service teachers seem averse to teaching high school students for the same reasons that high school and elementary pre-service teachers shun the middle grades. Specifically, the middle grades pre-service teachers believe that older students have attitude problems and are difficult to relate to. Further investigation is warranted regarding the bases that pre-service teachers draw conclusions about problems teaching at other levels. In particular, what life experiences or academic studies fueled their adversity to teaching different age levels? How well informed are they, especially related to teaching science to high school students? The pre-service teachers in this

study were well informed of the relatively positive employment market for middle school teachers. This presents an attraction to emphasize when recruiting science teachers for the middle grades.

Last, some pre-service middle school and elementary teacher candidates found the content course requirements for middle school science teacher certification daunting. A year of calculus was a roadblock for many when considering middle school science teaching. The benefits and barriers of specific content requirements warrants investigation in terms of its impact on attracting students to middle school science certification degree programs.

High School Pre-Service Science Teachers

Unlike middle school pre-service teachers who may later want to move up to teaching in grades 9-12, high school pre-service teachers seem unlikely to move down to the middle grades. High school teachers' preferences for their grade level appears to be founded on two relatively fixed factors, the high level of science content at high school and the students' recent maturation to higher thinking levels. Consequently, it may be difficult to attract them to teach at the lower level of middle school science content. Also, two findings emerged which are consistent with conclusions about elementary and middle grades pre-service teachers. First, high school pre-service teachers are rarely recruited into teaching. Second, high school pre-service teachers had positive experiences when they were a student at their favored 'age' group. This presents an additional research question: what experience have they had and how might this influence their choice for the upper grades? Surprisingly, high school pre-service teachers seem unaware of the positive employment market that they will encounter; this may be an attraction to emphasize in science teacher recruiting. Some respondents were very interested in "other subjects", specifically sports and coaching, which might present an avenue for recruiting pre-service science teachers in these areas.

Conclusion

This study reveals factors that may influence pre-service teachers to choose science as their teaching field, identifies avenues for recruiting pre-service teachers to science, and uncovers questions that need to be further addressed in order to more effectively attract teachers to teach science. We have determined unique factors within our sample at each level that may influence more students to consider science teaching at the middle and high school levels. The elementary pre-service teachers, in noticeable contrast to secondary teachers, were more likely to have reported having experiences with their age level students. Providing secondary teacher candidates with opportunities to work across all student age groups may result in increasing interest in teaching at the high need secondary levels. This teacher preparation approach is used by UTeach, a nationally recognized science teacher preparation program at the University of Texas at Austin, as the foundation for their STEP courses (UTeach, 2011). Interestingly, in our study one pre-service high school interviewee reported that the experience of tutoring her 10^{th} grade cousin and his friends in biology "opened her mind" to teaching high school science. At our university we have recently started a National Science Teacher Association [NSTA] student chapter that involves all three levels of pre-service teachers. Students in the chapter have opportunities to talk with each other, to tutor secondary students in science, be judges at middle and high school science fairs, go on science field trips, etc. We consider the NSTA chapter an opportunity for pre-service teachers to gain additional experiences with middle and high school students.

The middle school pre-service teachers were more likely to know their employment market.

Pre-service elementary teachers appeared unaware of the relatively poor elementary teaching employment market. We assume that they are unaware of the relatively stronger market for teaching science. To recruit more high school pre-service teachers at our university, more information needs to be provided to incoming students concerning the dire employment look for elementary level teachers and the urgent need for more high school science teachers. Within the last year, the advising offices of our Colleges of Science and Education have teamed together to produce a joint website to better inform students of the employment outlook at the various levels.

Both elementary and middle grades pre-service teachers were averse to some of the content courses typically required for science teacher preparation at the secondary levels. As teacher educators we need to investigate their specific aversions and how to mitigate them, and also we need to help build students' confidence with these content areas. At our university, as a result of this study we found that a full year of calculus was a "roadblock" for some students that prevented them from considering middle school science teaching. We examined the grade 4-8 science certification degree plans from four other leading universities that prepare future teachers in our state and determined the typical mathematics requirements for middle school science teachers. After meetings with mathematics professors in our College of Science, we have successfully chartered a more appropriate degree plan that includes both calculus and statistics for pre-service middle school science teachers. We determined through discussion with the mathematics faculty that the application of mathematics through statistics may have greater applicability in the middle school science classroom. The new degree plan has been implemented in our College of Education.

The high school pre-service teachers were more likely to prefer older students at their age levels whereas both elementary and middle school pre-service teachers preferred the younger students at their age levels. Preference for students' age as compared to preference to teach science content shifted among the participant groups with elementary teachers being driven more by their age preferences and high school teachers by content preference. We feel that providing more experiences with secondary students through an NSTA chapter or other means might lead high school pre-service teachers to feel more comfortable with younger age students. The pre-service high school science teachers were also interested in sports and coaching. This may present a recruiting avenue: recruit middle and high school students with a passion for sports and coaching. We have initiated a collaboration with our physical education department, the Department of Health and Human Performance, to modify their degree programs to include life science teacher certification.

We have determined common factors within our sample at each level that may influence more students to consider science teaching at the middle and high school levels. Across all three levels, having a "good science teacher" was a factor that influenced pre-service teachers to want to teach science. Consequently, professional development efforts that strengthen today's teachers in grades K-16 may influence more teacher candidates to prepare for science teaching careers. This leads to a long-term avenue for recruiting. As science teacher educators, we need to partner with and support today's science teachers to help insure that all students have good experiences in science class.

Across all three levels, almost none of the pre-service teachers had been actively recruited into teaching, and none into science. Clearly, this presents an opportunity to build the future pool of science teachers. As mentioned earlier, science teacher educators could partner with their university's student advising centers to help inform teacher candidates about attractive career opportunities in science teaching.

We recognize that generalization of the study's findings is limited by our sample size and the self-reporting instrumentation. We propose further validation of our findings through a larger

sample of pre-service teachers. We also suggest that further investigation be directed at how pre-service teachers form their preferences and aversions for specific age groups, most notably middle school students, and what factors lead them to specific aversions to some teacher preparation content courses.

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Amerikan fen öğretmen adaylarının profilleri: Kopacak fırtına ortasında koruma

Amerika Birleşik Devletlerindeki ve tüm dünyadaki fen öğretmenlerinin sayısal azlığı mevcut fen öğretmenlerini tutma ve daha fazla öğrenciyi fen eğitimi alanlarına yönlendirmede kollektif bir ihtiyacı işaret etmektedir. Bu çalışma Amerika Birleşik Devletleri servis öncesi fen öğretmenlerini nelerin cezp ettiğini ve cesaretini kırdığını araştırmaktadır. Tarama ve yapılandırılmış görüşme yaklaşımlarını kullanarak fennin öğretimi ile ilgilenen ilköğretim, ortaöğretim öğretmen adaylarının(n=109) profillerini araştırdık. Bu fen öğretmen adaylarından elde edilen ortak bulgular şunlardır: çocuklukları sürecinde K-12 öğretmenleri ile olumlu fen tecrübeleri, belli öğretmen hazırlık kurs içeriklerinin onaylanmış olmaya engel oluşturması, fen öğretmenleri için iş pazarına yabancılık ve fen öğretimine yabancılık. Fen öğretmen adaylarının bu profil özellikleri temelinde öğretmen eğitimcileri daha fazla öğretmen adayının feni öğretim alanı olarak seçmesi için izleyebilirler.

Anahtar kelimeler: servis-öncesi, fen öğretmen adayları, profiller, iyileştirme