# THE LONGITUDINAL EFFECTS OF THE TAMU NOYCE SCHOLARS PROGRAM ON STEM TEACHERS' CLASSROOM INSTRUCTION AND PERCEPTIONS OF TEACHING

A Dissertation

by

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Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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December 2017

Major Subject: Curriculum and Instruction

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## ABSTRACT

Staffing high schools with highly qualified mathematics and science teachers continues to be a challenge for school districts across the U.S. One way to address this challenge is to offer financial incentives, in the form of scholarships or grants, for high performing college students to become high school mathematics or science teachers. It is not clear, however, the effects these types of scholarship programs have on the recruitment, retention, and classroom contexts of the students who receive the scholarships. More research in this area is needed.

One of the most well-known scholarship programs for prospective mathematics and science teachers is The Robert Noyce Teacher Scholarship Program (Noyce Program). This dissertation contains three studies that examine the effects a Noyce Program had on a group of Robert Noyce Scholarship recipients. More specifically, the studies investigate (a) the perceptions of STEM teaching and decisions participants made regarding STEM teaching, (b) the influence of the Noyce Program on the Scholars' decisions to teach in high-need schools, stay in high-need schools, and the effects of the program on the Scholars themselves, and (c) the interactions and behaviors observed in participants' classrooms as well as their overall classroom contexts.

Sixty-one participants were recruited (29 experimental group, 32 control group) for the three-year longitudinal, quasi-experimental study. Quantitative and qualitative data were collected via annual surveys, bi-annual classroom observations, and annual telephone interviews. Descriptive statistics, exploratory factor analysis, and statistical methods for comparing means were used to analyze the quantitative data. A modified version of Burnard's (1991) general inductive approach was used for qualitative data analysis.

Findings indicate some statistically significant differences between groups in a number of areas and researchers found the Noyce Program had positive effects on the Noyce Scholars' financial status, overall sense of well-being, and opportunities for professional development. Further findings indicate the scholarship had little influence on their decisions to become a teacher or stay in a high-need school setting.

## DEDICATION

To my husband, Larry, and my two boys, Russ and Jay.

## ACKNOWLEDGEMENTS

I would like to express my deepest thanks to the many people who encouraged, supported, and guided me through this journey. First, I would like to start with my committee members. To Jane Schielack for her words of wisdom and planting the seed in my head that I should pursue such a degree. I appreciate you investing your time in my future, pushing me to achieve higher goals, and for being a friend to lean on. To Mary Margaret Capraro for agreeing to taking on the massive job of guiding me through this journey. Your advice, patience, support, confidence in my abilities, friendship, and most of all, your never-ending smile made this an enjoyable four years. To Hersh Waxman for the excellent courses, the confidence in my work, the guidance in data analysis, and the support you provided while I juggled multiple duties. You have been a true blessing for me. To Radhika Viruru for your advise on qualitative methods, your encouragement throughout the years, and votes of confidence throughout the process was amazing. Finally, to Timothy Scott; your endless words of encouragement, confidence in my abilities, and flexibility with work duties truly helped me get to the end. Your patience with me throughout the years of this journey was endless and I am very privileged to have you as a colleague, a friend, and a mentor.

Now, to my family; first, to my husband, Larry, for being patient during stressful deadlines, tending to the kids, taking care of things while I stared endlessly at the computer screen, and for never giving any hint that you wanted me to quit. This is just as much your dissertation as it is mine; I love you Larry. To my sons; Russ and Jay. The time we lost together while I completed this dissertation will be all worth it in the end. I cherish your constant words of encouragement; the words “I can’t wait to call you doctor, mom” were a true motivation for

me. Words cannot express how thankful I am for the two of you; I love the both of you dearly. To my mother-in-law Davelyn and fathers-in-law Tom and Travis. The three of you were strong pillars in this journey and I am extremely lucky to have such supportive, loving, and awesome in-laws.

Finally, to my mom, my dad, and my uncle Donny; my mother instilled in me at a young age that you finish what you start and this life lesson is definitely one that helped me reach this finish line. Thank you mom, your support in anything I have done has been endless. To my dad, who passed years ago and never even knew I started a doctoral program; I know he would have been ecstatic to see me graduate and I can only imagine the party he would have thrown for such an accomplishment. To uncle Donny who I know would have loved to attend the graduation, but I just couldn't get this done quick enough for him to be a part of the celebration. My last words to you on the phone contained a promise to walk the stage in 2017, and for you I have pushed to do this. I will miss seeing your white hair and crazy colored pants at graduation, but you will remain in my heart.

## CONTRIBUTORS AND FUNDING SOURCES

This work was supported by a dissertation committee consisting of Professor Mary Margaret Capraro (advisor), Hersh Waxman (co-advisor), and Radhika Viruru of the Department of Teaching, Learning, and Culture and Professor Jane Schielack of the Department of Mathematics. Other contributors to this work are Timothy P. Scott of the College of Science, Manjari Banerjee of the Department of Teaching, Learning, and Culture, Paige Milburn of the College of Science, Melissa Ross, Amanda Puckett, Stephanie Rayburn, and Georgia Bartlett. All other work conducted for the dissertation was completed by the student independently.

Funding for this study was supported by a Robert Noyce Teaching Grant sponsored by the National Science Foundation (DUE #1439907).

## NOMENCLATURE

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| AERA | American Educational Research Association |
| COM | Classroom Observation Measure |
| DBST | Decisions on becoming a STEM Teacher |
| EFA | Exploratory Factor Analysis |
| EI | Employment Information |
| IHE | Institution of Higher Education |
| ITCJ | Impressions of Teaching and Current Job |
| NCES | National Center for Educational Services |
| NCTM | National Council for Teachers of Mathematics |
| NS | Noyce Scholarship |
| NSF | National Science Foundation |
| NSTA | National Science Teacher Association |
| OCOS | Overall Classroom Observation Schedule |
| PGE | Plans for Graduate Education |
| PI | Personal Information |
| SASS | Schools and Staffing Survey |
| SCTA | School Climate and Teacher Attitudes |
| SOS | Student Observation Schedule |
| SPSS | Statistical Package for the Social Sciences |
| STEM | Science Technology Engineering and Mathematics |
| TAMU | Texas A&M University |

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|---|---|
| TEACH | Teacher Education Assistance for College and Higher Education |
| TOS | Teacher Observation Schedule |
| TP | Teacher Preparation |
| TSP | Teacher Scholarship Program |
| UMN | University of Minnesota |

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# CHAPTER I

# INTRODUCTION

Robert Noyce was one of the first scientists to work in Northern California. His contributions to the science, technology, engineering, and mathematics (STEM) fields earned him the nickname "the mayor of Silicon Valley", a stretch of Northern California now commonly referred to as the Silicon Valley. He was co-founder of both Fairchild Semiconductor and Intel Companies and is credited with inventing the integrated chip; an invention now used in the building of the microprocessors that power today's computers (Bradley, 2014). Robert Noyce's impact on the technology industry was monumental, but after his death in 1990 his name became recognizable in the education industry too. The Robert Noyce Teacher Scholarship Program is now a signature effort of the National Science Foundation (NSF) to prepare a new generation of mathematics and science teachers.

The Robert Noyce Teacher Scholarship Program (Noyce program) is one example of a U.S. Government initiative that was enacted to address the critical need of teachers in high-need fields, specifically the high-need fields of STEM. This scholarship program encourages talented STEM students to pursue teaching careers in mathematics and science by providing institutions of higher education funding to recruit "individuals with strong STEM backgrounds who might otherwise not have considered a career in K-12 teaching" (National Science Foundation, 2012, p. 7). Begun by an Act of Congress in 2002, the Robert Noyce Teacher Scholarship program was reauthorized under the America COMPETES Act in 2007 and the American COMPETES Reauthorization Act of 2010. The program was designed to increase the number of STEM teachers with strong STEM content knowledge to teach in high-need school districts. STEM

students who are awarded the scholarship receive substantial funds–sometimes as much as $20,000–and usually participate in special opportunities in high-need school settings. As part of their scholarship, recipients are required to complete one year of teaching in a high-need public school district for each semester of financial support. For example, if a student is awarded four semesters of scholarship funding he or she in turn agrees to teach in a high-need public school district for four years. If scholarship recipients do not fulfill the teaching commitment, then they must pay back the funds in the form of an interest-bearing loan.

## Statement of the Problem

In the U.S. there is a lack of supply of teachers in high-need areas of bilingual education, foreign language, mathematics, science, and special education (U.S. Department of Education, 2014). The continual lack of effective teachers in the high-need fields has negatively impacted the quality of instruction and has created a cycle of ineffective teaching in classrooms that has numerous adverse implications (Darling-Hammond, 2007). This problem is even more acute in schools that serve a high percentage of families below the poverty line or have a high percentage of teachers teaching out of their field. Focusing on recruiting and retaining high quality, effective teachers in high-need areas has gained momentum in the national spotlight and is now at the forefront of many political initiatives. To address the critical need of teachers in the identified shortage areas, various types of teacher incentive programs have emerged; the Noyce Program is one such a program.

The Noyce Program has awarded scholarships to a sizable number of high achieving STEM students throughout the United States. As of July 2017, the Noyce Program produced 10,196 new STEM teachers and 638 Master Teachers who either are teaching or have taught in high-need school districts throughout the country (S. Richardson, personal communication, July

24, 2017). This is evidence that high achieving STEM students are taking advantage of opportunities presented to them, but the actual impact the Noyce program has had on recruiting and retaining high-quality teachers in high-need schools is unclear. Would the students who received the Robert Noyce Teaching Scholarship (Noyce Scholars) have become teachers without the support of the Noyce program? The Noyce program does require students to teach in high-need schools, but it is uncertain if these students would have taught in high-need schools without the teaching commitment required by the Noyce program. High achieving STEM students are choosing teaching as a career, but the level at which the Noyce Program influences their decision to teach, to teach in high-need schools, to stay teaching in high-need schools, and the impacts of the program on their classroom instruction remains unanswered. Investigating the effects the Noyce Program has on the recruitment, retention, and classroom contexts of high school mathematics and science teachers warrants more research.

## Purpose of the Study

For this study, researchers focused on investigating the influences one Noyce Program at a university in the South-Central region of Texas had on its scholarship recipients. The purpose of this dissertation was to understand the Scholars' (a) perceptions of teaching and the teaching profession, (b) decisions as they relate to a career in teaching, and (c) classroom behaviors, interactions, and instruction. Through the investigations, researchers aimed to determine how the Noyce Program impacted recruitment and retention of STEM teachers as well as the overall classroom instruction and environment. A quasi-experimental design was chosen to help identify any characteristics, trends, or behaviors the Noyce Scholars had when compared to a group of students who did not receive the Noyce Scholarship. Identifying some of these factors unique to Noyce Scholars can help teacher preparation programs, other scholarship programs, and the

education profession in general better understand how to improve secondary STEM teacher recruitment, preparation, and retention.

## Literature Review

Uncovering the role that scholarships play in encouraging college students to enter the teaching profession in high-need schools is a complex task. Many factors contribute to the decisions students make to enter the teaching profession. Some scholarship recipients cite reasons like wanting to make a positive impact on society and children, teaching subject matter they are passionate about, and being a positive role model for children (Bull, Marks, & Salyer, 1994; Henry, Bastian, & Smith, 2012). Other scholars may have a biased portrayal of low-income urban areas and, as such, have more of a missionary perspective that drives them to enter the teaching profession and "save" the underprivileged students (Irizarry, 2009). Whatever the reasons, studying students' motivations for entering, and remaining, in the teaching profession is important if we are to completely understand the nuances of teacher recruitment and retention, especially in high-need settings.

Some work has been done on scholarship programs for teachers and the impact of the incentives on the recipients' decisions relative to teaching. The amount of funding that is awarded by the scholarship is one factor that has been found to impact scholars' decisions to accept the funding. Scholars were influenced more when the financial incentive covered a higher proportion of their tuition (Darling-Hammond, 2007; Henry et al., 2012; Liou & Lawrenz, 2011). Students who accepted competitive scholarships for teaching appear to have significantly higher academic credentials and high levels of compassion and humanity, however, unless the scholarship programs required recipients to work in high-need schools, they tended to teach in

schools and classrooms with more high-achieving students from higher-income families (Henry et al., 2012).

Research findings on the Noyce Scholarship seem to align with the findings on scholarship programs in general. The financial incentive offered by the Scholarship had the most influence on recruiting teachers to high-need schools and completion of certification programs, but less of an influence on the new teachers staying in a high-need school for long periods of time (Liou, Desjardins, & Lawrenz, 2010; Liou, Kirchhoff, & Lawrenz, 2010; Liou & Lawrenz, 2011). Additionally, the financial incentive did not influence their decisions to enter the teaching profession; many of the Scholars would have entered the teaching profession regardless of the financial incentive (Bull et al., 1994; Liou, Kirchhoff, & Lawrenz, 2010). For Scholars who had not originally considered teaching, however, Liou and Lawrenz (2011) found the financial incentive did have a larger impact on their decision to enter the teaching profession. Money from the Noyce Scholarship appears to have similar influences as other scholarship programs. Using scholarships as mechanisms to recruit teachers into the field and into teaching in high-need fields has its own set of challenges. Thus, it is necessary to continue to study these challenges and attempt to develop solutions that will better meet the needs of the forecasted teacher market.

## Research Questions

1. How do the Noyce Scholars perceptions of teaching and of the teaching profession differ from the perceptions of a group of non-Noyce Scholars who were certified through the same teacher preparation program?

2. How do Noyce Scholars decisions about becoming a teacher, about staying in the teaching profession, and about plans for graduate education differ from a group of non-Noyce Scholars who were certified through the same teacher preparation program?
3. What are the Noyce Scholars' perceived effects, influences, and impact of the Noyce Program?
4. How do Noyce Scholars' classrooms or teaching behaviors compare to those of the non-Noyce Scholars?
5. How do Noyce Scholars' students' behaviors compare to those of the non-Noyce Scholars?
6. How do Noyce Scholars' overall classroom environments compare to those of non-Noyce Scholars?

## Article 1: Comparing Robert Noyce Scholars and Non-Robert Noyce Scholars Perceptions of Teaching

For this study, a quasi-experimental design was used and researchers applied stratified matched sampling to compare the decisions and perceptions of participants who received a Noyce scholarship to those participants who did not receive a Noyce scholarship. Targeted participants were students who received their secondary mathematics or science teaching certification from a university in the southwestern region of the United States and who all participated in the same secondary undergraduate teacher preparation program. The data for this study was generated from one survey that was administered electronically to the 61 participants (29 Noyce Scholars and 32 non-Noyce Scholars) in the summer of 2015.

The survey used in this study was adapted from two other surveys; the Schools and Staffing Survey (SASS) created by the National Center for Educational Statistics (NCES) and

the Noyce Scholar Survey developed at the University of Minnesota for the Noyce Evaluation Report (University of Minnesota, 2012). The survey contained 70 questions that were classified in into nine sections: Personal Information (PI), Employment Information (EI), Decisions on Becoming a STEM Teacher (DBST), Mentoring and Induction Experiences (MIE), Impressions of Teaching and Current Job (ITCJ), Plans for Graduate Education (PGE), Teacher Preparation (TP), School Climate and Teacher Attitudes (SCTA), and the Noyce Scholarship (NS). The questions on the survey had a variety of answer types. Some questions used categorical scales, some were ordinal scales, and others were open-ended. Most of the ordinal scale questions had multi-part statements where participants ranked the statements on four- or five- point Likert scales. The full set of questions used for the survey can be found at http://aggieteach.tamu.edu/noyce-monitoring-and-evaluation-project.

The responses from the survey were analyzed to help determine any statistically significant differences between two independent groups of participants, Noyce Scholars and non-Noyce Scholars, across four categories of the survey. The four categories are: Decisions on Becoming a STEM Teacher (DBST), Plans for Graduate Education (PGE), Teacher Preparation (TP), and School Climate and Teacher Attitudes (SCTA). Some questions within categories were analyzed on a statement-by-statement basis and others had latent variables created via an exploratory factor analysis. For the latent variables, corresponding factor scores were calculated and Mann-Whitney U tests were used to determine any significant differences between the groups on both the latent variables and the statement-by-statement analysis. The two categories that produced statistically significant differences between groups were DBST and PGE. No statistically significant differences between Noyce Scholars and non-Noyce Scholars were found for the TP and SCTA categories.

**Article 2: Reflections from Noyce Scholars on their Route to STEM Teaching**

This study was a three-year longitudinal study. Researchers used a mixed-methods research design to investigate the Noyce Scholars' perceived effects of the Noyce Program on their recruitment and retention in high-need schools as well as the impact of the program on the Scholars overall. There were 29 participants in the study who all received a Robert Noyce Scholarship from the same university and graduated from the same teacher preparation program during 2002-2014. Of the 29 educators, 22 were classroom teachers and seven were school administrators.

The questions on the three summer surveys were adapted from two other surveys: the Schools and Staffing Survey (SASS) created by the National Center for Educational Statistics (NCES) and the Noyce Scholar Survey developed at the University of Minnesota for the Noyce Evaluation Report (University of Minnesota, 2012). Both surveys had previously undergone reliability and validity testing (Liou & Lawrenz, 2011; NCES, 2012). Questions for the semi-structured interview were extracted from interview questions developed at the University of Minnesota for the Noyce Evaluation Report (University of Minnesota, 2012). Appendix C lists the questions used in the semi-structured interviews.

Each of the three surveys contained 70 to 80 items classified into nine sections with a variety of scales of measurement: categorical, ordinal, and open-ended. Most of the ordinally-scaled questions had multi-part statements where participants ranked the statements on four- or five-point Likert scales. For this study, researchers only used questions from the Noyce Scholarship section of the surveys. The survey questions used for this study are listed in Appendix D.

Quantitative data were analyzed using descriptive statistics for each year of the study and for the summary across the three years. Qualitative data were analyzed using a modified version of the general inductive approach (Burnard,1991). This method assumes that semi-structured, open-ended interviews were carried out, the interviews were recorded in full, and all interviews were transcribed. Burnard's (1991) approach contains 13 stages, but for this study, some of the stages were modified and made more efficient with the use of qualitative data analysis software.

In Spring 2015 semi-structured telephone interviews were conducted, audio recorded and transcribed with the Noyce Scholars ($n$ = 29). In Summer 2015 ($n$ = 29), 2016 ($n$ = 27), and 2017 ($n$ = 28) electronic surveys were administered during the corresponding year. For this study, only interview and survey questions pertaining to teaching in high-need schools and the Noyce Scholarship Program were analyzed.

Results indicated the Noyce Scholarship did have effects on the Scholars that are in align with some, but not all, of the goals and objectives of the Noyce Program. Scholars reported the scholarship was not very influential in their decision to become a teacher, nor was it very influential in their decision to teach in a high-need school. The scholarship was, however, somewhat influential in the Scholars' decisions to stay in a high-need school for the full term of their commitment. Other effects the scholarship had on Scholars were improved financial status upon graduation of college, decreased time to graduation, improved networking with other teachers, the opportunity to attend state and national conferences, and improved emotional well-being while in college.

## Article 3: Impacts of Noyce Scholarship on Classroom Contexts of Secondary STEM Teachers

For this study, researchers used a quasi-experimental design and applied stratified matched sampling to compare the teaching behaviors, student behaviors, and the overall classroom environments of participants who received a Noyce scholarship to those participants who did not. Targeted participants were classroom teachers who received their secondary mathematics or science teaching certification through the same secondary undergraduate teacher preparation program. Data for this study were generated from five classroom observations that were conducted over five academic semesters: Spring 2015, Fall 2015, Spring 2016, Fall 2016, and Spring 2017. There were 51 participants in the study (22 Noyce Scholars and 29 non-Noyce Scholars).

Three instruments were used during each observation and each was adapted from instruments used in previous research studies. The instruments were a mix of low- and high-inference observations. The low-inference instruments used systematic observation methods that provide specific and easily identifiable behaviors easy for observers to code (Waxman, 2003). The high-inference instrument required observers to make a judgment based on a series of classroom constructs such as, "Teacher provided opportunities for students to be creative." The combination of instrument types helped collect information in a variety of forms and provided quantitative methods of data collection.

Data for each of the five observations were coded in a spreadsheet and averaged across the five observations for each participant. Descriptive statistics were calculated for each of the five observations and for the average of the five observations. The averaged data were used to report demographics along with the behaviors, interactions, and activities most frequently used

by both groups. Independent samples *t*-tests were calculated on all observations and the overall averaged data to identify any statistically significant differences between the groups' teaching, student behaviors, and overall classroom environments.

Overall, across the five observations, differences between the Noyce Scholars and the non-Noyce Scholars in the study were minimal. It appears the Noyce Scholars spent more class time demonstrating, questioning, and focusing on outcomes than the non-Noyce Scholars, but there is no way to know if this is because of their classification as a Noyce Scholar. The classroom contexts of all teachers in the study were of good quality especially as it relates to emotional and organizational support. Data indicated that teachers often had positive emotional and affective support in the classroom. Teachers were perceived to have warm supportive relationships with the students, and they fostered a classroom environment that supported risk-taking. Data also indicated the teachers actively facilitated the lessons to promote student interaction and engagement and did so in a way that encouraged participation, gave feedback, and monitored student work. These are indicators that the classrooms observed were positive environments for students to learn STEM content.

# CHAPTER II

# COMPARING ROBERT NOYCE SCHOLARS AND NON-ROBERT NOYCE SCHOLARS PERCEPTIONS OF TEACHING

The flow of new teachers into classrooms around regions of the U.S. is decreasing and this is changing the condition of the teacher pipeline. During the 20th century, the supply of teachers generally met the demand. New teachers viewed their job as a lifelong career from which they would retire, and experienced teachers made up the majority of teachers in the profession (Ingersoll & Merril, 2010; National Commission on Teaching and America's Future [NCTAF], 2010). At the end of the 20th century and beginning of the 21st century, however, the number of experienced teachers teaching in schools decreased (Carroll, 2007) and this change has affected the condition of the teacher pipeline.

At the beginning of the 21st century, new teachers started leaving the profession at detrimentally high rates. Though the estimates for beginning teacher attrition rates vary, it is evident that these rates are high and negatively impact both the teacher supply and teaching quality. Some researchers report that 30% of new teachers leave the profession within their first five years of teaching (Ingersoll & Merril, 2010; NCTAF, 2010) while others suggest higher rates between 40% and 50% (Grissmer & Kirby, 1987, 1992, 1997; Ingersoll, 2003). Though not all estimates are equal, the fact that about one in three new teachers leave the profession is evidence that the condition of the teacher pipeline is at risk.

The severity of the teacher shortage problem varies among grade levels, disciplines, and geographic areas. A teacher shortage area, sometimes referred to as a high-need area, is grade specific and subject matter discipline specific to the geographic area in which the U.S. Secretary

of Education determines there is an inadequate supply of teachers (U.S. Department of Education, 2014). Bilingual education, foreign language, mathematics, science, and special education are some of the examples of high-need teaching fields. The continual lack of effective teachers in these high-need fields has negatively impacted the quality of instruction and has created a cycle of ineffective teaching in classrooms that has numerous adverse implications (Darling-Hammond, 2007). This problem is even more acute in schools that serve a high percentage of families below the poverty line or have a high percentage of teachers teaching out of their field. Focusing on recruiting and retaining high quality, effective teachers in high-need areas has gained momentum in the national spotlight and is now at the forefront of many political initiatives.

The Robert Noyce Teacher Scholarship Program (TSP), funded by the National Science Foundation (NSF), is one example of a governmental initiative that was enacted to address the critical need of teachers in high-need fields, specifically the high-need field of science, technology, engineering, and mathematics (STEM). This scholarship program encourages talented STEM students to pursue teaching careers in mathematics and science by providing institutions of higher education (IHE) funding to recruit "individuals with strong STEM backgrounds who might otherwise not have considered a career in K-12 teaching" (National Science Foundation, 2012, p. 7). Begun by an Act of Congress in 2002, the Robert Noyce TSP was reauthorized under the America COMPETES Act in 2007 and the American COMPETES Reauthorization Act of 2010. The program was designed to increase the number of STEM teachers with strong STEM content knowledge to teach in high-need school districts. STEM students who are awarded the scholarship receive substantial funds – sometimes as much as $20,000 – and as part of their scholarship they are required to complete one year of teaching in a

high-need public school district for each semester of financial support. The Robert Noyce TSP has awarded scholarships to a sizable number of high achieving STEM students throughout the United States, but the actual impact the program has had on recruiting and retaining high-quality teachers in high-need schools is unclear.

Uncovering the role that scholarships play in influencing students to enter the teaching profession, and to teach in high-need schools, is a complex task. Many factors, both intrinsic and extrinsic, contribute to the decisions students make to enter the teaching profession. Some scholarship recipients cite reasons like wanting to change society and children, teaching subject matter they are passionate about, and being a positive role model for children (Bull, Marks, & Salyer, 1994; Henry, Bastian, & Smith, 2012) as reasons for entering the teaching profession. Other scholars may have a tainted portrayal of low-income urban areas and, as such, have more of a missionary perspective that drives them to enter the teaching profession and "save" the underprivileged students (Irizarry, 2009). This general desire to help others is a common characteristic found in effective teachers (Stronge, 2007). Internal factors, such as the ones mentioned above, contribute to the scholarship recipients' decisions to enter teaching, but there are also external reasons. Teaching scholarships is prime example of an external influencing force.

Scholarships that are designed to combat the teacher shortage problem and increase the number of teachers in high-need fields generally include some financial incentive. The extent to which the financial incentive effects the scholar's decision to become a teacher, or teach in low-income schools, is difficult to measure, but some work has been done to reveal contributing factors. One factor that was found to impact scholars' decisions to accept the funding was the amount awarded. Scholars' were influenced more when the financial incentive covered a higher

proportion of their tuition (Darling-Hammond, 2007; Henry et al., 2012; Liou & Lawrenz, 2011). For the Noyce Teaching Scholarship specifically, some research has shown that the financial incentive did not influence the scholars' decisions to enter the teaching profession; many of the Noyce Scholars would have entered the teaching profession regardless of the financial incentive (Bull et al., 1994; Liou, Desjardins, & Lawrenz, 2010). For those Noyce Scholars who might not have otherwise considered a career in teaching, however, the financial incentive had a larger impact on their decision to enter the teaching profession (Liou & Lawrenz, 2011). Competitive scholarships appear to attract individuals with significantly higher academic credentials and higher levels of human capital into teaching, but unless the scholarship programs require recipients to work in high-need schools, they tend to teach in schools and classrooms with more high-achieving and low-poverty students (Henry et al., 2012). The financial incentive offered by the Noyce Scholarship had the most influence on recruiting teachers to high-need schools and completing their certification program, but less of an influence on staying in a high-needs schools for long periods of time (Liou, Kirchhoff, & Lawrenz, 2010; Liou, Kirchhoff, & Lawrenz, 2010; Liou & Lawrenz, 2011). Using scholarships as a mechanism to recruit teachers into the field and into teaching in high need fields has its own set of challenges. Thus, it is necessary to continue to study these challenges and modify them to meet the needs of the forecasted teacher market.

Though some research exists on factors that influence Noyce Scholars' decision to enter the teaching profession and how the financial incentive of the scholarship impacted their decision to teach, little research has been conducted on characteristics unique to Noyce Scholars. Comparing the perceptions of the Noyce Scholars on various aspects of teaching and the teaching profession with a similar group of teachers that did not receive the Noyce scholarship

can possibly shed some light on differences between Noyce Scholars and non-Noyce Scholars. The research questions guiding this study are:

1. How do the Noyce Scholars perceptions of teaching and of the teaching profession differ from the perceptions of a group of non-Noyce Scholars who were certified through the same teacher preparation program?
2. How do Noyce Scholars decisions about becoming a teacher, about staying in the teaching profession, and about plans for graduate education differ from a group of non-Noyce Scholars who were certified through the same teacher preparation program?

## Methods

### Design

For this study, we used a quasi-experimental design and applied stratified matched sampling to compare the characteristics and perceptions of participants who received a Noyce scholarship to those participants who did not. Targeted participants were students who received their secondary mathematics or science teaching certification from a university in the southwestern region of the United States and who all participated in the same secondary undergraduate teacher preparation program. The data for this study were generated from one survey that was administered electronically to 61 participants during the summer of 2015.

### Participants

The pool of participants for this study was comprised of teachers who were all certified from the same teacher preparation program during 2002-2014. The teacher preparation program from which the participants graduated was a secondary, undergraduate program at a large, research university located in the South Central region of Texas. The program certifies students who are working toward a bachelor's degree in mathematics or science to be teachers in Texas

secondary schools. Each student in the program takes at least 18 hours of education courses, observes in secondary schools for at least 120 hours, and completes either a 12-week student teaching experience or a one-year internship. All participants in this study received their initial teaching certification for either grades 7 or 8 to 12.

From 2002-2007, and again from 2009-2014, the preparation program received two Robert Noyce Teaching Scholarship Grants providing funds to award high achieving students a scholarship to help fund their education. Each student was a mathematics or science major with at least a 3.0 average. At the beginning of each academic semester, a selection committee was appointed to review the applications and select a set of Noyce Scholars. Throughout the 10 years of funding, 71 students from preparation program were selected as Noyce Scholars.

The Noyce Scholars received $5,000 each semester for a minimum of one and a maximum of four semesters while agreeing to teach in a high-need school district for one year. If the agreement was not fulfilled, they had to pay back the money awarded in scholarship funds as an interest-bearing loan.

At the time of this study, 61 of the 71 The TPP Noyce Scholars were employed in the education profession and thus were eligible to participate in the study. Of the 10 ineligible, one was in graduate school, six no longer had valid teaching certificates, one was teaching out of the state, and no contact information was found for the remaining two. Email messages were sent to all 61 eligible scholars inviting them to participate with a stipend of $675. Fifteen did not respond (of those 6 bounced back), 19 declined to participate in the study, and 29 agreed to participate in the study.

The selected control group of 178 (referred to as non-Noyce Scholars) was comprised of teachers who were certified through the same teacher preparation program during 2002-2014, but

who did not receive a Noyce Scholarship. An email message was sent describing the terms of the study with a stipend of $675. Three rounds of email messages were sent to the control group and 130 did not respond (9 bounced back), 9 declined to participate in the study, and 39 agreed to participate in the study (22% response rate).

Table 1. Demographics and Employment Characteristics of Study Participants

| Characteristic | Noyce | Non-Noyce | Total |
|---|---|---|---|
| Gender | | | |
| Female | 19 | 26 | 45 |
| Male | 10 | 6 | 16 |
| Ethnicity | | | |
| White, Non-Hispanic | 26 | 28 | 54 |
| Black, Non-Hispanic | 1 | 0 | 1 |
| Hispanic | 1 | 2 | 3 |
| Asian or Pacific Islander | 1 | 1 | 2 |
| Other | 0 | 1 | 1 |
| School Locale | | | |
| City: Large/Midsize/Small | 4/2/2 | 6/2/4 | 10/4/6 |
| Rural: Fringe/Distant | 6/0 | 3/3 | 9/4 |
| Suburb: Large | 10 | 8 | 18 |
| Town: Distant/Fringe/Remote | 0/0/3 | 2/2/0 | 2/2/3 |
| 2014-2015 Job Title | | | |
| School Administrator | 5 | 1 | 6 |
| District Level Administrator | 0 | 1 | 1 |
| Classroom Teacher | 20 | 27 | 47 |
| Other | 4 | 3 | 7 |
| Number of Years of Experience | | | |
| 0 | 2 | 1 | 3 |
| 1-3 | 10 | 14 | 28 |
| 4-5 | 8 | 10 | 18 |
| > 5 | 11 | 8 | 19 |

The 39 non-Noyce Scholars who agreed to participate in the study were stratified on two items - school locale code and years of experience in the education profession - and matched to

the 29 selected Noyce Scholars. The school locale code (National Center for Educational Statistics, 2006) classifies schools based on its proximity to an urbanized area. The number of years of experience were examined and matched, as close as possible, to the school locale code and number of years of experience of the Noyce Scholars. This process resulted in the omission of seven non-Noyce Scholars and created a sample size of 29 (Noyce Scholars) and 32 (non-Noyce Scholars). This was intentional to account for any attrition that could occur throughout the three years of the larger, longitudinal study. Summaries of the demographics and employment characteristics of the participants are shown in Table 1.

**Instrumentation**

The Summer 2015 survey was adapted from two other surveys; the Schools and Staffing Survey (SASS) created by the National Center for Educational Statistics (NCES) and the Noyce Scholar Survey developed at the University of Minnesota for the Noyce Evaluation Report (University of Minnesota, 2012). Questions were selected from these two surveys because both survey instruments had been previously administered and were found to be reliable and valid (NCES, 2012; Liou & Lawrenz, 2009). Additionally, using questions adapted from these surveys allows for comparison of the results from other studies.

The Summer 2015 survey contained 70 questions that were classified in into nine sections: Personal Information (PI), Employment Information (EI), Decisions on Becoming a STEM Teacher (DBST), Mentoring and Induction Experiences (MIE), Impressions of Teaching and Current Job (ITCJ), Plans for Graduate Education (PGE), Teacher Preparation (TP), School Climate and Teacher Attitudes (SCTA), and the Noyce Scholarship (NS).

The questions on the survey had a variety of answer types: categorical scales, ordinal scales, and open-ended. Most of the ordinal scale questions had multi-part statements where participants ranked the statements on four- or five- point Likert scales.

**Procedures**

Each participant completed the survey. Questions from the categories of PI, EI, MIE, and NS were not used because the categories did not align with the research questions guiding this study. Additionally, because of the similarity of the questions in the categories ITSC and SCTA, ITSC questions were merged into SCTA creating four categories to be analyzed: DBST, PGE, TP, and SCTA

Each category contained either ordinal or nominal scales. DBST and PGE each contained two nominal scale questions; TP contained two ordinal scale and one nominal scale question; and SCTA contained 10 ordinal scale and three nominal scale questions, giving a total of eight nominal scale and 12 ordinal scale questions. These ordinal scales each had multiple statements that participants rated on 4- or 5-point Likert-type scales ranging from “Strongly Agree” to “Strongly Disagree”.

For the eight questions with nominal scales either the Mann-Whitney U or the Chi-Square test was used to determine any significant differences between participants who received a Noyce scholarship and those who did not. For the 12 ordinal scale questions, an Exploratory Factor Analysis (EFA) was conducted to determine the factor structure of the statements within each question. For seven of the 12 ordinal scale questions, the individual EFAs identified that all statements within the question loaded on a single factor that accounted for between 44 to 70% of the variance for each factor. The Cronbach’s Alpha for each of the factors was greater than 0.70 ($\alpha > 0.70$). For each of these seven latent variables, the following scales were named:

Performance of School Leadership, Problems in Schools, Perceptions of Actual Control in the Classroom, Teacher Influence Over School Policy, Perceptions of Preparedness for 1st Year of Teaching, Opportunities within Teacher Certification Program, and Perceptions of Formal Evaluations. Table 2 shows the Cronbach's alpha, the eigenvalue, and the percent variance explained by each of the seven latent variables.

For the remaining five questions that did not load on a single factor with $\alpha > 0.70$, further analysis was required. Four had $\alpha < 0.70$ and the fifth question loaded on multiple factors, but did not have meaningful groupings. Thus, a reliability analysis was conducted to determine if the alpha value would increase if some statements with each question were omitted. For two, it was determined that the alpha value would increase and exceed 0.70 if some of the statements were omitted. Thus, this statement was omitted to increase $\alpha$ to 0.726 and for the other question, two statements were omitted to increase $\alpha$ to 0.748. Two latent variables were created for these two questions; Perceptions of State Assessments and Job Satisfaction and Enthusiasm. Table 2 shows the Cronbach's alpha, eigenvalue, and the percent variance explained by each of these two latent variables.

Table 2. Cronbach's Alpha, Eigenvalues, and Percent Variance for Seven Latent Variables

| Latent Variable | Category | Cronbach's Alpha | Eigenvalue | % variance explained |
|---|---|---|---|---|
| Performance of School Leadership | SCTA | 0.91 | 4.913 | 61.414 |
| Problems in Schools | SCTA | 0.905 | 5.472 | 54.718 |
| Perceptions of Actual Control in the Classroom | SCTA | 0.776 | 2.986 | 49.768 |
| Teacher Influence Over School Policy | SCTA | 0.778 | 3.112 | 44.462 |
| Perceptions of Preparedness for 1st Year of Teaching | TP | 0.878 | 4.409 | 55.118 |
| Opportunities within Teacher Certification Program | TP | 0.823 | 2.673 | 66.814 |
| Perceptions of Formal Evaluations | SCTA | 0.768 | 2.09 | 69.665 |
| Perceptions of State Assessments* | SCTA | 0.726 | 2.17 | 45.783 |
| Job Satisfaction and Enthusiasm** | SCTA | 0.748 | 2.56 | 51.296 |

* one statement removed ** two statements removed

For the third of the four questions that underwent the additional reliability analysis, the alpha value still did not exceed 0.70 when the statements were omitted. For this question, an alpha value of 0.662 was deemed acceptable and a scale titled School Environment was created. The School Environment scale had an eigenvalue of 1.999 and this variable explained 49.974% of the variance. The alpha value for the fourth question that underwent additional reliability analysis would not increase to an acceptable alpha level ($\alpha = 0.383$), hence this question was analyzed on a statement-by-statement basis with a Mann-Whitney U test.

For the one ordinal scale question that loaded on multiple factors but did not have meaningful groupings, further reliability analysis was conducted, but it continued to fail to have meaningful groupings where all alpha values exceeded 0.70. The first EFA on this question revealed five factors, but none of the statements within the factors could be labeled with a meaningful title and $\alpha > 0.70$ for some of the factors by $\alpha < 0.70$ for other factors. Thus, additional EFAs were conducted that forced the statements to load on four, three, two, and one factor. For all of these four EFAs, reliability and creating meaningful groupings continued to be

a problem resulting in this question being analyzed on a statement-by-statement basis with a Mann-Whitney U test.

Thus, after all EFAs and additional analyses were conducted, it was determined that of the 12 ordinal scale questions, 10 loaded on individual factors and two did not load sufficiently on any factors. As such, ten latent variables were created and statement-by-statement analyses were conducted on the two questions that failed the EFA. The 10 latent variables and the two questions analyzed on a statement-by-statement basis did not meet the normal distribution assumption and equal variance requirement for parametric tests, so Mann-Whitney U tests were conducted throughout the study to determine any significant differences between participants who received a Noyce scholarship and those who did not. For the latent variables, factor scores were calculated and used in the Mann-Whitney U tests.

## Results

In this study, the responses from the survey were analyzed to help determine any statistically significant differences between two independent groups of participants across four categories of the survey. The four categories were: Decisions on Becoming a STEM Teacher (DBST), Plans for Graduate Education (PGE), Teacher Preparation (TP), and School Climate and Teacher Attitudes (SCTA). Some questions within categories were analyzed on a statement-by-statement basis and others had latent variables created via an Exploratory Factor Analysis. For the latent variables, corresponding factor scores were calculated and Mann-Whitney U tests were used to determine any significant differences between the groups on both the latent variables and the statement-by-statement analysis.

**Decisions on Becoming a STEM Teacher (DBST)**

The DBST category contained two nominal scale questions. The first question was "Did any of the following help you decide to become a STEM teacher?". A list of nine statements followed this question and participants responded to each statement with "yes" or "no". A Mann-Whitney U test produced statistically significant difference between the groups on two of the nine statements. For the first significant statement, "I like the flexibility and/or autonomy of STEM teaching.", results of the Mann-Whitney U test ($p = 0.011$) indicated that non-Noyce participants were influenced more by the flexibility and/or autonomy of STEM teaching ($M = 0.88$, $SD = 0.336$) than the Noyce participants ($M = 0.59$, $SD = 0.501$). Glass' effect size value ($\Delta = 0.863$) suggested a high practical significance.

The second significant difference found in the first question concerned the statement "I feel that a teaching career is/will be conducive to my family life". Results of the Mann-Whitney U test ($p = 0.005$) indicated that non-Noyce participants were influenced more by a teaching career being conducive to family life ($M = 0.88$, $SD = 0.336$) than Noyce participants ($M = 0.55$, $SD = 0.506$). Glass' effect size value ($\Delta = 0.982$) suggested a high practical significance. Table 3 shows the descriptive statistics and results of the Mann-Whitney U test on all nine statements.

Table 3. Descriptive Statistics and Mann-Whitney U Test Results for the Question "Did any of the following help you decide to become a STEM teacher?"

| Question | Noyce | | Non-Noyce | | Mean | |
|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Diff | M-W U |
| I like sharing my subject with others. | 0.93 | 0.258 | 0.94 | 0.246 | -0.01 | $p$ =.92 |
| I like working with young people. | 1.03 | 0.186 | 1.03 | 0.177 | 0 | $p$ =.944 |
| I like having summers off. | 0.76 | 0.435 | 0.75 | 0.44 | 0.01 | $p$ =.938 |
| I like the flexibility and/or autonomy of STEM teaching. | 0.59 | 0.501 | 0.87 | 0.336 | -0.28 | $p$ =.011* |
| I feel that a teaching career is/will be conducive to my family life. | 0.55 | 0.506 | 0.87 | 0.336 | -0.32 | $p$ =.005* |
| I feel that I have a talent for teaching STEM. | 0.9 | 0.31 | 0.87 | 0.336 | 0.03 | $p$ =.794 |
| I feel this career allows me to 'make a difference' in the world. | 0.97 | 0.186 | 0.97 | 0.177 | 0 | $p$ =.944 |
| I have family members that are/were teachers. | 0.55 | 0.506 | 0.62 | 0.492 | -0.07 | $p$ =.564 |
| Other people encouraged me to become a STEM teacher. | 0.38 | 0.494 | 0.47 | 0.507 | -0.09 | $p$ =.484 |

The second question in the DBST category that produced a statistically significant difference ($p$ = 0.033) between non-Noyce ($M$ = 1.69, $SD$ = 0.471) and Noyce participants ($M$ = 1.41, $SD$ = 0.501) was "At what point in your life did you decide to become a STEM teacher?". For this question, participants chose one of the following three responses: Childhood/adolescence (age 18 or before), Early adulthood (age 19-22), or Adulthood (age 23 or older).

For the analysis, Childhood/adolescence was coded as "1", Early adulthood as "2", and Adulthood and "3". The frequency counts indicate that significantly more Noyce participants decided to become a STEM teacher at the age of 18 ($n$ = 17) than non-Noyce ($n$ = 12). Additionally, significantly more non-Noyce participants decided to become a STEM teacher

between the ages of 19 and 22 ($n$ = 22) than Noyce ($n$ =10). Glass' effect size value ($\Delta = 0.594$) suggests a moderate practical significance.

**Plans for Graduate Education (PGE)**

The PGE category contained two dichotomous (yes or no), nominal scale questions. For the first, "Since graduating from the university have you taken any graduate level classes?", a chi-square test indicated a statistically significant difference $\chi^2(1)=4.601$, $p < 0.05$ between groups indicating that significantly more Noyce participants (55%) took some graduate level classes since graduating from the university than non-Noyce (28%). For the second question, "Since graduating from the university have you received any advanced degrees?", a chi-square test indicated a statistically significant difference $\chi^2(1)=4.824$, $p < 0.05$ between groups indicating that significantly more Noyce participants (45%) received advanced degrees since graduating from the university than non-Noyce (19%).

**Teacher Preparation (TP)**

The TP category contained one nominal scale question that contained multiple dichotomous statements and two latent variables (formed in the EFA). The dichotomous statements were analyzed for differences between groups on a statement-by-statement basis. The two latent variables in TP were: (a) Opportunities within Teacher Certification Program and (b) Preparedness for 1st Year of Teaching.

The nominal scale question, "Which of these were part of your experience in your teacher certification program?", was analyzed on a statement-by-statement basis with participants responding with "yes" or "no" to a list of 14 statements. A Mann-Whitney U test indicated a statistically significant difference between the groups on only one statement - "Opportunities to interact with children from different cultures" ($p$ = 0.043) indicating that Noyce participants had

significantly more opportunity to interact with children from different cultures ($M$ = 1.34, $SD$ = 0.484) than the non-Noyce participants ($M$ =1.12, $SD$ = 0.336). Glass' effect size value ($\Delta$ = 0.655) suggested a moderately high practical significance. The descriptive statistics and results of the Mann-Whitney U test for each statement within this question are provided in Appendix A.

The two latent variables for the TP category were Opportunities within Teacher Certification Program ($M$ = 0.004, $SD$ = 0.922) and Preparedness for 1st Year of Teaching ($M$ = -0.176, $SD$ = 1.01). A Mann-Whitney U test found no statistically significant differences between the two groups. The Opportunities within Teacher Certification latent variable had four statements that participants rated on a 5-point scale. The statements related to the question "In your teacher certification program, how much opportunity did you have to do the following" with 5 representing "Extensive Opportunity" and 1 represented "none". The means from each group ranged from 2.28 to 3.13. The Preparedness for 1st Year of Teaching had eight statements that participants rated on a 4-point scale. The statements referred to the prompt "In your first year of teaching, how well prepared were you to…" and the ratings ranged from 1 (not at all prepared) to 4 (very well prepared). The means from each group ranged from 2.14 to 3 with the exception of the statement "Teach your subject matter". For this statement, Noyce Scholars had a slightly lower means ($M$ = 3.31) than the non-Noyce Scholars ($M$ = 3.53).

**School Climate and Teacher Attitudes (SCTA)**

The SCTA category contained 13 questions (3 were categorical and 10 were ordinal). The three categorical questions were analyzed on a statement-by-statement basis for differences between groups. The results of the EFA indicated that two of the 10 ordinal questions needed to be analyzed as individual questions for differences between groups. Thus, this category contained five statement-by-statement analyses. Latent variables were created for the remaining

eight ordinal questions and their corresponding factor scores were analyzed for differences among groups.

The first of the three categorical questions were “How long do you plan to remain in your current position?”. Participants chose from eight statements (as long as I am able, until I am eligible for retirement benefits from this job, until I am eligible for Social Security benefits, until a specific life event occurs (e.g., parenthood, marriage), until a more desirable job opportunity comes along, definitely plan to leave as soon as I can, undecided at this time, other) and results of a Mann-Whitney U test indicated no statistically significant difference among groups. Table 4 shows the percentage of Noyce and non-Noyce scholars that selected each statement. Those participants that selected “other” reported the following statements when asked to specify: one more year, as long as it is a good position for my family, for several years before moving into administration, until I reach retirement age and then I would like to work in academia teaching others how to teach, until I become a professor, and I am working on acquiring a principal position in the coming years.

Table 4. Percentage of Each Group's Responses to Question "How long do you plan to remain in your current position?".

| Statement | Noyce | Non-Noyce |
|---|---|---|
| As long as I am able. | 41% | 56% |
| Until I am eligible for retirement benefits from this job. | 0 | 0 |
| Until I am eligible for retirement benefits from a previous job. | 0 | 0 |
| Until I am eligible for Social Security benefits. | 0 | 0 |
| Until a specific life event occurs (e.g., parenthood, marriage). | 4% | 9% |
| Until a more desirable job opportunity comes along. | 21% | 3% |
| Definitely plan to leave as soon as I can. | 0 | 0 |
| Undecided at this time. | 24% | 22% |
| Other | 10% | 10% |

The second categorical question was “If you could go back to your college days and start over again, would you choose to teach again or not?”. Participants ranked their responses on a 5-point scale. The percentages of responses to this question are show in Table 5. Results of the Mann-Whitney U test indicated no statistically significant difference among groups for any of these responses.

Table 5. Percentage of Responses to Question "If you could go back to your college days and start over again, would you choose to teach again or not?".

| | Certainly would (5) | Probably would (4) | Chances are about even (3) | Probably would not (2) | Certainly would not (1) | Mean | *SD* |
|---|---|---|---|---|---|---|---|
| Noyce | 73% | 17% | 10% | 0 | 0 | 4.62 | 0.677 |
| non-Noyce | 60% | 25% | 12% | 3% | 0 | 4.41 | 0.837 |

The third categorical question was “Which of the following describes your employment during the 2014-2015 school year?”. Percentages and descriptive statistics for this question are show in Table 6. Results of the Mann-Whitney U test ($p = 0.016$) indicated that significantly more Noyce participants were employed in a high-needs schools ($M = 1.28$, $SD = 0.591$) than the non-Noyce participants ($M = 1.46$, $SD = 0.647$). The participants that chose the response “other” reported that they were not sure of their school’s high-need status.

In the SCTA category there were two ordinal questions that did not reliably load on a factor. The first question was “How much do you agree or disagree with each of the following statements about teaching?”. Participants ranked the five statements relating to satisfaction with their current job on a 5-point scale from “Strongly Agree” to “Strongly Disagree”. A Mann-Whitney U test was conducted on a statement-by-statement basis but no statistically significant

results were found. Table 7 shows the descriptive statistics and results of the Mann-Whitney U test.

Table 6. Percentages and Statistics for the Question "Which of the following describes your employment during the 2014-2015 school year?".

| | I worked in high needs (3) | I worked in another type of school (2) | Other (1) | Mean | *SD* |
|---|---|---|---|---|---|
| Noyce | 79% | 14% | 7% | 1.28 | 0.591 |
| non-Noyce | 47% | 44% | 9% | 1.46 | 0.647 |

Table 7. Descriptive Statistics and Results of Mann-Whitney U test for Question "How much do you agree or disagree with each of the following statements about teaching?".

| Statements | Noyce | | non-Noyce | | Diff. of | |
|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Means | M-W-U |
| I am satisfied with my current job. | 4.41 | 0.628 | 4.22 | 0.941 | 4.31 | $p$ =.455 |
| I really dislike STEM teaching. | 1.1 | 0.557 | 1.41 | 0.712 | 1.26 | $p$ =.090 |
| If I had to do it all over again, I would choose the same teacher preparation program and/or route into teaching. | 4.34 | 0.814 | 4.44 | 0.759 | 4.39 | $p$ =.657 |
| If I had to do it all over again, in view of my present knowledge, I would become a teacher. | 4.34 | 0.721 | 4.34 | 0.701 | 4.34 | $p$ =.961 |
| I am likely to assume a leadership position (e.g., lead teacher, depart. chair, official or unofficial mentor) | 3.48 | 1.805 | 3.66 | 1.335 | 3.57 | $p$ =.816 |

The second question that did not reliably load on a factor was “To what extent do you agree or disagree with each of the following statements?”. Participants ranked 18 statements relating to various aspects of school climate and teacher attitudes on a 4-point scale from “Strongly Agree” to “Strongly Disagree”. A Mann-Whitney U test was conducted on a

statement-by-statement basis but no statistically significant results were found. The descriptive statistics and results of the Mann-Whitney U test for this question are shown in Appendix B.

Finally, a Mann-Whitney U test was conducted on the eight latent variables associated with this category. The eight latent variables were: Performance of School Leadership, Problems in Schools, Perceptions of Actual Control in the Classroom, Teacher Influence Over School Policy, Perceptions of Formal Evaluations, School Environment, Perceptions of State Assessments, and Job Satisfaction and Enthusiasm. A Mann-Whitney U test indicated no statistically significant differences between the groups on any of the eight latent variables. The Performance of School Leadership latent variable had eight statements that participants rated on a 5-point scale. The statements related to the question "How effectively do you feel the principal or school head performed each of the following at last year's school" and the ratings ranged from 1 (not at all effectively) to 5 (extremely effectively). The means of both groups ranged from 2.97 to 3.69.

The Problems in Schools latent variable had ten statements that participants rated on a 4-point scale. The statements related to the question "To what extent is each of the following a problem in this school?" with ratings from 1 (not a problem) to 4 (serious problem). The means of both groups ranged from 1.75 to 2.83.

The Perceptions of Actual Control in the Classroom latent variable had six statements that participants rated on a 4-point scale. The statements related to the question "How much actual control do you have in your classroom at your last school over the following areas of your planning and teaching?". Ratings ranged from 1(no control) to 4 (a great deal of control). The means of both groups ranged from 2.5 to 3.77.

The Teacher Influence Over School Policy latent variable had seven statements that participants rated on a 4-point scale. The statements related to the question "How much actual influence do you think teachers have over school policy at your last school in each of the following areas?". Ratings ranged from 1(no influence) to 4 (a great deal of influence). The means of both groups ranged from 1.66 to 2.48 with higher means of 2.59 (Noyce) and 3.22 (non-Noyce) for the one statement regarding establishing curriculum.

The Perceptions of Formal Evaluations latent variable had three statements that participants rated on a 4-point scale. The statements related to the question "To what extent do you agree or disagree with each of the following statements about the formal evaluation of your work as a teacher last school year?". Ratings ranged from 1 (strongly disagree) to 4 (strongly agree). The means of both groups ranged from 2.94 to 3.67.

The School Environment latent variable had four statements that participants rated on a 5-point scale. The statements related to the question "Please rate your school environment as high, medium, or low on the features listed below.". Ratings ranged from 1 (very low) to 5 (very high). The means of both groups ranged from 3.28 to 3.9.

The Perceptions of State Assessments latent variable had five statements that participants rated on a 4-point scale. The statements related to the question "To what extent do you agree or disagree with each of the following statements about the state assessment program during the 2014-2015 school year?". Ratings ranged from 1 (strongly disagree) to 4 (strongly agree). The means of both groups ranged from 2.74 to 3.32 with the exception of one statement. The statement I did not receive adequate support in preparing my students for the assessments had means of 1.79 (Noyce) and 1.73 (non-Noyce).

The Job Satisfaction and Enthusiasm latent variable had seven statements that participants rated on a 4-point scale. The statements related to the question "To what extent do you agree or disagree with each of the following statements?". Ratings ranged from 1 (strongly disagree) to 4 (strongly agree). The means, each posed in a negative connotation, of both groups ranged from 1.47 to 2. The means on the other two statements, each posed in a positive connotation, of both groups ranged from 2.97 to 3.28.

## Discussion

The impact that scholarships related to teaching have on recruiting and retaining high-quality teachers in high-need schools is unclear. This is also true of the Robert Noyce Teaching Scholarship. Some research exists on factors that influence Noyce Scholars' decision to enter the teaching profession and how the financial incentive of the scholarship impacted their decision to teach, but little research can be found on characteristics special to Noyce Scholars. If some profiling of the Noyce Scholar can be done, then universities can use the information during the recruiting and preparation phase to improve teaching and teacher preparation.

In this study, four categories were analyzed to investigate the perceptions and characteristics of Noyce Scholars about teaching and the teaching profession. The four categories were Decisions on Becoming a STEM Teacher (DBST), Plans for Graduate Education (PGE), Teacher Preparation (TP), and School Climate and Teacher Attitudes (SCTA). To aid in identifying any perceptions and characteristics unique to Noyce Scholars across these categories, data was compared to a group of non-Noyce Scholars who received their teacher training from the same teacher preparation program. Non-parametric inferential statistics used on the data indicated some significant differences between groups across three of the four categories.

In the DBST and PGE categories, the results indicate that differences between Noyce Scholars and non-Noyce Scholars do exist. The Noyce Scholars, in general, made decisions about their future plans at younger ages and for different reasons than the non-Noyce Scholars. Significantly more Noyce Scholars decided to become teachers before the age of 18 than non-Noyce Scholars and external factors like flexibility or autonomy of STEM teaching and conduciveness to family life seemed to be less of an influence on their decisions to teach. This suggests that during their high school years, Noyce Scholars are actively thinking about their future careers; they are early career deciders. Noyce Scholars may be giving more weight to reasons such as "love of a subject" and "making a difference in the world" than reasons like "flexibility or autonomy of STEM teaching" and "conduciveness to family life" for deciding to be a teacher. Noyce Scholars appear to be less influenced during their college-aged years on making a career choice since many of them made the decision before 18. Non-Noyce Scholars, on the other hand, seem to enter college undecided on a career choice and maybe more influenced by external factors when choosing a career. Thus, when recruiting teachers into the profession during the college years, external factors like "flexibility or autonomy of STEM teaching" and "conduciveness to family life" may be good aspects of the teaching profession to highlight to recruit college aged students into the teaching profession or at least to get them thinking about selecting teaching as a career.

Results in the PGE category also indicate that Noyce Scholars decide to invest in their graduate education at a higher rate than their non-Noyce counterparts. This could be due, in part, to the funds that the Noyce Scholars received as undergraduates or that Noyce Scholars were academically successful students. Receiving the scholarship funds as an undergraduate could have put the Noyce Scholars in a position where they had less student loan debt and thus, more

willingness to invest money in graduate studies. This notion cannot be fully supported by the results of this study, but it is something that could be explored in future studies. Additionally, Noyce Scholars were required to have a 3.0 grade point average to be eligible for the scholarship. This prerequisite condition for the scholarship may play a role in the motivation for Noyce Scholars to seek more graduate education than the non-Noyce Scholars. Nonetheless, this supports the notion that Noyce Scholars make decisions about their future earlier than the non-Noyce Scholars.

Results in the TP category indicate that there are few differences between groups regarding the participants' perceptions of their preparedness for 1st year of teaching and the opportunities with the teacher preparation program. This is not surprising because all participants in the study were similarly trained. The opportunity to interact with children from difference cultures showed Noyce Scholars reporting more opportunity to interact with children from different cultures during their teacher preparation than non-Noyce Scholars. Again, this is not surprising because of the structure of the program. Noyce Scholars were required to tutor, mentor, or assist with groups of children that came from the lower socioeconomic sub-groupings.

Results in the SCTA category imply little difference between groups regarding the participants' perceptions on school climate and teacher attitudes. There was only statistically significant difference between groups and that was in the type of school (high-needs or not) in which the participants were employed. This finding, however, is not surprising given that Noyce Scholars agreed to teach in a high-needs school district when they accept the Noyce Teaching Scholarship. Thus, this finding seems to be influenced by the requirements of the Noyce Scholarship program and is also in align with current research on scholarship programs; the financial incentive has most influence on recruiting teachers to high-need schools.

Though there is little difference among groups in the SCTA category, the results of the analysis do indicate that the overall perception of the participants regarding school climate and teacher attitudes is fairly positive. Most of the participants expressed a desire to stay in the profession and also indicated they would choose to teach again given the opportunity to start their college days over. The lowest scores were in the Teacher Influence Over School Policy indicating that participants had minor to moderate influence over school policy. Further research could investigate relationships between teachers' attitudes toward the profession and their perceived influence over school policy. Future studies could also try to include greater incentives for participating in the study in order to obtain a more representative sample.

# CHAPTER III

# REFLECTIONS FROM NOYCE SCHOLARS ON THEIR ROUTE TO STEM TEACHING

When the supply of well-trained professionals does not meet demand, stakeholders oftentimes focus on incentive programs to increase supply. The medical, military and education professions have used these techniques to increase the supply of nurses, soldiers, and teachers respectively. Assistance offered by each incentive program varies, as do the terms and conditions of the agreement. In education, for example, some incentive programs are scholarship-based and offer aid to college students while others offer loan-forgiveness incentives for students who teach in schools serving low-income families. Yet other programs offer tuition-for-service forms of financial aid in which students' tuition is paid for in return for a teaching commitment. Regardless of the incentive program, increasing the supply of well-trained professionals to meet demand is imperative to maintaining quality public service, especially in the public service sector of education.

In the U.S., the teacher supply is low and the need is more critical in some areas than others. High poverty and high minority settings are the areas of utmost concern as they take the brunt of the teacher shortage problem (Sutcher, Darling-Hammond, & Carver-Thomas, 2016). In all 50 states there are multiple disciplines, grade levels, and special services listed on the annual teacher shortage report (U.S. Department of Education, 2016) and the areas of mathematics, science, and technology are some of the content areas that are most prevalent (Sutcher et al., 2016; U.S. Department of Education, 2016). To address the critical need of teachers in the identified shortage areas, various types of teacher incentive programs have emerged.

Individual states have designed incentive programs for teachers that are aligned with the particular needs of the state. The Underwood-Smith Teacher Scholarship, created for West Virginia college students, is one such example. This scholarship program provides eligible students $5000 annually in return for a teaching commitment in West Virginia schools. Scholarship recipients must teach for a period of two years for each year the scholarship is awarded. The teaching commitment is reduced to one-year if the recipient teaches in a high-need school (College Foundation of West Virginia, 2017).

The state of New York has developed a number of teacher incentive programs aimed at recruiting a broader range of teacher candidates. The New York City Department of Education established the Teach NYC Scholarship program (New York City Department of Education, 2005). This program offers graduate level scholarships for students interested in teaching bilingual, special education, science, English as a new language, physical education, mathematics, and early childhood. The program offers uncertified candidates a path to certification by way of a Master's degree in the identified teaching or clinical shortage area. Additionally, the New York State Education Department implemented the Teachers of Tomorrow program (New York State Education Department, 2017). This is a tuition-reimbursement program offering incentives to encourage qualified individuals to become faculty in the state's highest-need schools.

The federal government has a few initiatives that incentivize college students to become teachers. One example is the Teacher Education Assistance for College and Higher Education (TEACH) Grant. The TEACH Grant provides eligible recipients up to $4000 annually in return for a four-year teaching commitment in a high-need field at a school that serves low-income students. To be eligible for the TEACH grant, students must be enrolled in a college or university

that has teacher training programs for students to be highly qualified teachers in a high-need field that leads to a bachelor's or master's degree, or is a post-baccalaureate program (U.S. Department of Education Office of Federal Student Aid, n.d.-b). A second initiative of the federal government is the Perkins Loan which offers loan-forgiveness for students with economic need and who, after graduation, are employed in a public service position or as a teacher in a school that serves low-income families (U.S. Department of Education Office of Federal Student Aid, n.d.-a).

One of the most well-known scholarship programs for prospective mathematics and science teachers is The Robert Noyce Teacher Scholarship Program (Noyce Program). This program is a government initiative funded by the National Science Foundation (NSF) and enacted to address the critical need of teachers in high-need fields of science, technology, engineering, and mathematics (STEM). This scholarship program encourages talented STEM students to pursue teaching careers in mathematics and science by providing institutions of higher education funding to recruit "individuals with strong STEM backgrounds who might otherwise not have considered a career in K-12 teaching" (National Science Foundation, 2012, p. 7). Begun by an Act of Congress in 2002, the Robert Noyce Teacher Scholarship program was reauthorized under the America COMPETES Act in 2007 and the American COMPETES Reauthorization Act of 2010. The program was designed to increase the number of STEM teachers with strong STEM content knowledge to teach in high-need school districts. STEM students who are awarded the scholarship receive substantial funds – sometimes as much as $20,000 ($5000 per semester for junior and senior year) – and usually participate in special opportunities in high-need school settings. As part of their scholarship, recipients are required to complete one year of teaching in a high-need public school district for each semester of financial

support. If scholarship recipients do not fulfill the teaching commitment, they must pay back the funds in the form of an interest-bearing loan.

These types of teacher incentive programs are designed to encourage students to enter the teaching profession. Students may take advantage of programs that offer scholarships, tuition reimbursement, tuition waivers, or loan-forgiveness, but little is known about the impact these programs have on the students and the teaching profession. There is scant research on whether these programs help solve the teacher shortage problem. Furthermore, there is little evidence that suggests these incentive programs are increasing the quality of instruction in the classroom. To investigate some of these questions, the current study examines one particular incentive program - the Noyce Program.

To date, the Noyce Program has produced 10,196 new STEM teachers and 638 Master Teachers who either are teaching or have taught in high-need school districts throughout the country (S. Richardson, personal communication, July 24, 2017). This suggests that high achieving STEM students are taking advantage of opportunities presented to them, but the actual impact the Noyce Program has had on recruiting and retaining high-quality teachers in high-need schools is unclear. Would the students who received the Robert Noyce Teaching Scholarship (Scholars) have become teachers without the support of the Noyce Program? The Noyce Program does require students to teach in high-need schools, but it is uncertain if these students would have taught in high-need schools without the teaching commitment required by the Noyce Program. High achieving STEM students are choosing teaching as a career, but the level at which the Noyce Program influenced their decision to teach, and teach in a high-need school, remains uncertain.

Uncovering the role that scholarships play in encouraging college students to enter the teaching profession in high-need schools is a complex task. Many factors contribute to the decisions students make to enter the teaching profession. Some scholarship recipients cite reasons like wanting to make a positive impact on society and children, teaching subject matter they are passionate about, and being a positive role model for children (Bull, Marks, & Salyer, 1994; Henry, Bastian, & Smith, 2012). Other scholars may have a biased portrayal of low-income urban areas and, as such, have more of a missionary perspective that drives them to enter the teaching profession and "save" the underprivileged students (Irizarry, 2009). Whatever the reasons are, studying students' motivations for entering, and remaining, in the teaching profession is important if we are to completely understand the nuances of teacher recruitment and retention, especially in high-need settings.

Some work has been done on scholarship programs for teachers and the impact of the incentives on the recipients' decisions relative to teaching. The amount of funding that is awarded by the scholarship is one factor that has been found to impact scholars' decisions to accept the funding. Scholars were influenced more when the financial incentive covered a higher proportion of their tuition (Darling-Hammond, 2007; Henry et al., 2012; Liou & Lawrenz, 2011). Students who accepted competitive scholarships for teaching appear to have significantly higher academic credentials and high levels of compassion and humanity, however, unless the scholarship programs required recipients to work in high-need schools, they tended to teach in schools and classrooms with more high-achieving and fewer students of poverty (Henry et al., 2012).

Research findings on the Noyce Scholarship seem to align with the findings on scholarship programs in general. The financial incentive offered by the Scholarship had the most

influence on recruiting teachers to high-need schools and completion of certification programs, but less of an influence on the new teachers staying in a high-need school for long periods of time (Liou, Desjardins, & Lawrenz, 2010; Liou, Kirchhoff, & Lawrenz, 2010; Liou & Lawrenz, 2011). Additionally, the financial incentive did not influence their decisions to enter the teaching profession; many of the Scholars would have entered the teaching profession regardless of the financial incentive (Bull et al., 1994; Liou, Kirchhoff, & Lawrenz, 2010). For Scholars who had not originally considered teaching, however, Liou and Lawrenz (2011) found the financial incentive did have a larger impact on their decision to enter the teaching profession. Money from the Noyce Scholarship appears to have similar influences as other scholarship programs.

Using scholarships as a mechanism for recruitment and retention of teachers in high-need fields requires further research. The current research pool is minimal and more studies on the impacts these efforts have on teachers and the teaching profession are needed. Thus, the research question guiding this particular study, which examined the Noyce Program at one public university, was: What are the Noyce Scholars' perceived effects, influences, and impacts of the Noyce Program?

## Methods

### Sample Description

Twenty-nine participants were recruited for this study. All participants (Scholars) received a Robert Noyce Teaching Scholarship from the same undergraduate secondary teacher preparation program housed at a large research university in South Central Texas. The teacher preparation program required at least 18 credit hours of education courses, at least 120 hours of observation in secondary schools, and completion of either a 12-week student teaching experience or a one-year internship. In addition, the Scholars obtained a bachelor's degree in a

STEM related field and were required to maintain a 3.0 GPA throughout their undergraduate career. As Noyce Scholars, all participants agreed to teach in a high-need school district for one to four years; depending on the amount they were awarded. Some demographics of the Scholars are displayed in Table 8.

Table 8. Demographics of the Participant Noyce Scholars

| | Male | | Female | | Total |
|---|---|---|---|---|---|
| | Math | Science | Math | Science | |
| Role in Education | | | | | |
| Classroom Teacher | 4 | 3 | 10 | 5 | 22 |
| Administrator | 2 | 1 | 1 | 1 | 5 |
| Counselor | 0 | 0 | 1 | 1 | 2 |
| Years in Profession* | | | | | |
| 0 to 3 | 1 | 2 | 5 | 1 | 9 |
| 4 to 6 | 1 | 1 | 3 | 1 | 6 |
| > 6 | 4 | 1 | 4 | 5 | 14 |
| Teaching Commitment** | | | | | |
| 1 year | 1 | 0 | 0 | 0 | 1 |
| 2 years | 2 | 2 | 4 | 3 | 11 |
| 3 years | 1 | 1 | 0 | 1 | 3 |
| 4 years | 2 | 1 | 8 | 3 | 14 |
| Ethnicity | | | | | |
| White, Non-Hispanic | 6 | 3 | 11 | 6 | 26 |
| Black, Non-Hispanic | 0 | 0 | 0 | 1 | 1 |
| Hispanic | 0 | 0 | 1 | 0 | 1 |
| Asian or Pacific Islander | 0 | 1 | 0 | 0 | 1 |
| Total | 6 | 4 | 12 | 7 | 29 |

*Calculated from the beginning of the study.
**High-need school district teaching commitment required by Noyce Program.

Participants in this study received their initial Texas teaching certification for mathematics or science in grades 7 (or 8) through 12 sometime between 2002 and 2014; the years in which the university received monies to award Noyce scholarships. In 2002-2007, and again from 2009-2014, the university's preparation program received two NSF-funded Robert Noyce Teaching Scholarship Grants. Throughout the 10 years of funding, 71 students were awarded as Scholars.

During the recruitment phase of the study, 61 of the 71 Scholars were employed in the education profession and thus eligible to participate in the study. Of the 10 ineligible participants, one was in graduate school, six no longer had valid teaching certificates, one was teaching out of the state, and no contact information was found for the remaining two. Email messages were sent to all 61 eligible Scholars inviting them to participate with a stipend of $675. Fifteen did not respond (of those 6 had no functional email address), 19 declined to participate in the study, and 29 agreed to participate in the study (48% response rate). All 29 who agreed to participant in the study were accepted. Because this sample contained Scholars who were still in the education profession and willing to participate for the full three-years of the study, this study is subject to sample bias. The attitudes and perceptions of Scholars who did not agree to participate may be very different than those who did, thus, possibly resulting in a study that does not provide as wide a range of perceived effects and influences of the Noyce Program as possible.

Throughout the three years of the study, two Scholars dropped out because they voluntarily left the teaching profession. The first dropped in June 2015 after the first year of the study because the cost to put the children in daycare was too high and the profit margin between cost of daycare and net monthly salary was too small to justify the time away from the children. The second Scholar dropped in June 2016, after the second year of the study, because of a perceived lack of influence over school policies and practices. This Scholar decided to pursue a full-time vocation to ministries overseas. The loss of these two Scholars has little effect on this study because both participated in the first year interview and at least the first year survey.

**Data Collection**

This was a three-year (August 2014 to June 2017) longitudinal study, a design chosen so the changes in participants' attitudes or perceptions of teaching and the teaching profession could be studied. This type of design allowed for repeated measures over time, which captured a more complete picture of the participants' attitudes and perceptions as they encountered different student populations and other cultural transitions that occurred in schools. In an attempt to reduce the variability in participants, researchers were interested in recruiting a group of Noyce Scholars who were all alumni from the same university and who all matriculated through the same teacher preparation program. Thus, purposive sampling (Etikan, Musa, & Alkassim, 2016) was used, and researchers deliberately chose the group of Noyce scholars who received Noyce Scholarship funds from the same university during the years 2002-2014.

Across the three years of the study both quantitative and qualitative data were collected via surveys and interviews. Participants completed a total of three surveys where approximately 90% of the questions were the same during each administration allowing for comparison of participants' responses from year to year. The surveys were distributed to the participants each June from 2015 to 2017 and had a mix of ordinal, categorical, and open-ended questions. The ordinal and categorical questions were used to collect quantitative data and the open-ended questions to collect qualitative data. Additionally, each spring, from 2015 to 2017, qualitative data were collected via semi-structured interviews. For this study, however, only data from Spring 2015 interviews were used because they were the only interviews that had questions created specifically for the Noyce Scholars about the Noyce Program. One member of the research team conducted all the Spring 2015 interviews across a three-month period. This mixed-methods research design allowed for a deeper understanding of the attitudes, perceptions,

and impacts the Noyce Program had on the Scholars. The rich descriptions from the qualitative data in the open-ended survey questions and interview data helped to compliment and provide a context for the quantitative data collected from the ordinal and categorical survey questions.

The one researcher who conducted all the interviews was an adviser for the same teacher preparation program in which the participants attended. The interviewer became a program adviser in March 2011 and thus knew some of the Scholars who were awarded the scholarship during the 2009-2014 funding period. The interviewer was also familiar with the type of teacher preparation the Scholars received, though the interviewer was never an instructor in any of the education courses the Scholars enrolled in as undergraduates. The interviewer's role in the teacher preparation program could have affected some of the Scholars' responses. For example, some of the Scholars who knew the interviewer may have felt more comfortable than other Scholars and thus may have provided more open and honest interview responses. Other Scholars may have felt they could not be as open for fear of offending or insulting the interviewer and may not have given as honest and open responses. Because there was no real consequence for expressing negative opinions and because the interviewer reiterated this at the beginning of the interview, researchers have no reason to believe that knowing the interviewer resulted in a large bias for data collection.

**Instrumentation**

The questions on the three summer surveys were adapted from two other surveys: the Schools and Staffing Survey (SASS) created by the National Center for Educational Statistics (NCES) and the Noyce Scholar Survey developed at the University of Minnesota for the Noyce Evaluation Report (University of Minnesota, 2012). Both surveys had previously undergone reliability and validity testing (Liou & Lawrenz, 2011; NCES, 2012). Questions for the semi-

structured interview were extracted from interview questions developed at the University of Minnesota for the Noyce Evaluation Report (University of Minnesota, 2012). Appendix C lists the questions used in the semi-structured interviews.

Each of the three surveys contained 70 to 80 items classified into nine sections with a variety of scales of measurement: categorical, ordinal, and open-ended. Most of the ordinally-scaled questions had multi-part statements where participants ranked the statements on four- or five-point Likert scales. For this study, researchers only used questions from the Noyce Scholarship section of the surveys. The survey questions used for this study are listed in Appendix D.

**Data Analysis**

Descriptive statistics were used to analyze the quantitative data for each of the three summer surveys and the final summary of all three years. Qualitative data from the semi-structured interviews and open-ended survey questions were analyzed using a modified version of the general inductive approach (Burnard, 1991). This method was chosen because it follows the same process used to conduct the interviews. Burnard's process assumes that semi-structured, open-ended interviews were carried out, the interviews were recorded in full, and all interviews were transcribed. For the Spring 2015 interviews, one researcher from the research team conducted the semi-structured interviews across a 3-month period, audio recorded each of the interviews, and then sent the audio files to a third-party company for transcription.

Burnard's (1991) approach contains 13 stages, but for this study, some of the stages were modified and made more efficient with the use of qualitative data analysis software. Though one researcher conducted all the interviews (Stage 1), two researchers participated in the coding and data analysis (Stages 2-13). The two researchers involved in the coding process were both former

high school mathematics teachers pursuing doctoral degrees. Their paths had crossed for personal reasons three years prior to this study; they had a positive working relationship and felt very comfortable openly expressing their thoughts and opinions. One of the two was the same researcher that conducted the interviews; she was an adviser for the teacher preparation program and was familiar with the university's Noyce Program. The second researcher was not familiar with the Noyce Program prior to starting the data analysis for this study. She did, however, help conduct the Spring 2017 interviews that helped her better understand the context of the overall research project. The backgrounds of these two researchers provided balance to the coding process; their different perspectives and positive working relationship allowed for opportunities to check and balance and better control for bias.

To begin the qualitative data analysis, the two researchers independently read all transcripts ($n$=29), made notes about general themes, and then met to discuss the themes each researcher identified. Next, they randomly chose four transcripts to read independently and each researcher created categories that captured the overall themes within the transcripts. The researchers met again to discuss the similarities and differences among their independently created categories. At the end of this meeting the two researchers created an agreed upon coding scheme and then applied the new coding scheme to the same four transcripts previously selected. A series of meetings followed, with additional randomly selected transcripts, until the two researchers reached approximately 75% inter-rater agreement. After this, the remaining transcripts were divided equally among the researchers and coded independently. After the coding process was completed, researchers analyzed the comments within the codes and grouped the comments by agreed upon themes. These themes were then clustered and the comments were organized accordingly. The final themes that emerged from the coding process were (a)

influences on decision to work in high-need schools, (b) influences on retention in high-need schools, (c) financial aspects, (d) improved emotional well-being, (e) professional development and networking, and (f) suggestions for improvement. The stages used to analyze the qualitative data for this study are outlined in Table 9 and the final coding scheme used in the analysis is displayed in Table 10.

Table 9. Outline of the Stages Used to Analyze and Code the Qualitative Data

| Stage | Description |
|---|---|
| 1 | Interviews were conducted, recorded, and transcribed. Notes were made after each interview about the topics discussed. |
| 2 | All transcripts were read and notes were made throughout the reading on general themes within the transcripts. |
| 3 | Two researchers independently read four randomly selected transcripts (T1, T2, T3, T4) line by line and answered repeatedly the questions "What is this about? What is being referenced here?" While reading, each researcher independently created a set of abstract and concrete categories that represented themes of the transcripts. These categories were compared to the notes made in stage 2. |
| 4 | The two researchers met to analyze the categories generated during Stage 3. Similarities and differences among the lists were examined. Categories that had similar interpretations were collapsed and common naming conventions were agreed upon. Categories that had different interpretations were discussed and merged with other categories. At the end of this stage, an agreed-upon set of codes and a description of each code was created. |
| 5 | The two researchers coded the same four transcripts (T1, T2, T3, T4) and applied the agreed upon coding scheme. Notes were made about possible adjustments to the coding scheme. |
| 6 | The two researchers met and compared the coding of each of the four transcripts (T1, T2, T3, T4). Discussions about discrepancies in the coding were conducted and adjustments in the coding of the transcripts were made. A final version of the coding was agreed upon for the four transcripts and a final set of codes. The two researchers created a final list of the codes and description of each code. |
| 7 | The two researchers independently coded four more transcripts (T5, T6, T7, T8) with the final coding scheme. |
| 8 | The two researchers met and compared the coding of the second set of four transcripts (T5, T6, T7, T8). Adjustments in the coding of the transcripts were made, but the coding scheme remained unchanged. The ~75% inter-rater agreement was reached. |
| 9 | Remaining transcripts were divided up among the two researchers. |
| 10 | All coding was done using ATLAS.ti, a qualitative data analysis software program. Using ATLAS.ti, researchers sorted the transcripts by codes and were careful not to alter the context of the transcript segment. As such, the researchers coded part of the interview question to preserve the context of the response. |
| 11 | Some interviewees were selected to check the appropriateness of the coding scheme on their responses. Feedback obtained at this stage was used to make appropriate adjustments to the coding scheme, but for this study, no changes were necessary. |
| 12 | Atlas.ti was used for the final sorting of the transcript codes was done using ATLAS.ti. The two researchers read the codes and grouped into themes when appropriate. |

Note: This is a modified version of methods described by Burnard (1991).

Table 10. Final Coding Scheme used to Analyze Interviews and Open-ended Survey Questions

| Code | Relates to statements regarding…. |
|---|---|
| HighNeedSchool–No | The participant is not working in high-need school, |
| HighNeedSchool–Yes | The participant is working in high-need school. |
| HighNeedSchool–WhyStayOrLeave | Why the participant stays or leaves high-need schools. |
| HighNeedSchool–WhyNotNoyce | Why the participant choose to teach in a high-need school and the statement does not mention Noyce as a reason/factor. |
| HighNeedSchool–WhyNoyce | Why the participant choose to teach in a high-need school and the statement explicitly lists Noyce as a reason/factor. |
| HighNeedSchool–Continue | Whether the participant plans to continue to teach in a high-need school. |
| Money-Immediate | How the money from the Scholarship ed the participant immediately as an undergraduate student |
| Money-PG | How the money from the Scholarship ed the participant after they graduated from college. |
| Noyce – Extra Opportunities | Extra/special opportunities because they were Noyce Scholar (going to state, national level conference) |
| Noyce – Extra Requirement | Extra requirements the participant had as an undergraduate because she/he was a Noyce Scholar. (tutoring, GPA, seminars) |
| Noyce – Inservice Teacher Support | How the Noyce Program supported participant as in-service teachers |
| Noyce - Program Suggestions | Noyce Scholars perceptions on how the Noyce Program can be changed and/or improved. |

## Findings

All Scholars in this study were either fulfilling their teaching commitment or had already fulfilled their teaching commitment required by the Noyce Scholarship. Thus, all Scholars had either previously worked or were still teaching in a high-need school district. During the interviews, Scholars were asked if they were working on a high-need campus or not. Twenty Scholars (69%) reported they were working in a high-need school and nine (31%) reported they were not. Of the nine that were not working in a high-need school, two stated they were working in a high-need district but not on a high-need campus, one reported the current school was previously high-need until a new middle school opened, one did not know if the school was considered high-need, and all others did not elaborate. Data from the summer surveys support the

interview data. In Summer 2015, 23 Scholars (79%) indicated they worked in a high-need school and 6 (21%) reported they did not. For Summer 2016, 20 Scholars (74%) worked in high-need schools while 7 (26%) did not, and in Summer 2017, 19 Scholars (70%) worked in a high-need school while 9 (30%) did not. Thus, 70% to 79% of the Scholars stayed in high-need schools across the three years of the study. Because all of the Scholars had worked in a high-need school district at some point during their career, it seemed prudent to investigate the degree to which the scholarship influenced the Scholars' decision to enter the teaching profession and to commit to teaching, and remain teaching, in a high-need school.

**Influences on Decision to Work in High-Need Schools**

On the summer surveys, Scholars responded to questions relating to the level of influence the Noyce Program had on their decisions and commitment to teach and ultimately teach in high-need schools. The first set of questions related to the level of influence the scholarship money had on their decisions to enter the teaching profession; there were three questions in this set. The first was "How influential was the Noyce Scholarship money in your commitment to become a teacher?"; the second was "How influential was the Noyce Scholarship money in your commitment to complete the teacher certification program?"; and the third was "How influential was the Noyce Scholarship money in your commitment to take a teaching job?" For each of these questions Scholars rated the level of influence as very influential, somewhat influential, not very influential, and not at all influential. On average, across the three years of the study, Scholars reported the scholarship money was not very influential for any of these three questions. Data for the three questions are displayed in Table 11.

The second set of questions related to the level of influence the Noyce Program had on the Scholars' decisions to teach in high-need schools; there were two questions in this set. The

first question was “Would you have decided to teach in a high-need school if you hadn’t participated in the Noyce Scholarship Program?” In the analysis “yes” was scored as “1”, “possibly” was scored as “2”, and “no” was scored as “3”. On average, across the three years of the study, 46% of the Scholars answered “yes”, 42% “possibly” and 12% answered “no”. The overall mean for this question was 1.663 ($SD$ = 0.686) indicating that it was highly possible the Scholars would have decided to teach in a high-need school even if they had not participated in the Noyce Program. The second question was “How influential was the Noyce Scholarship money in your commitment to teach in a high-need school?” and Scholars rated the level of influence as very influential, somewhat influential, not very influential, and not at all influential. On average, across the three years of the study, Scholars reported the Noyce Scholarship was somewhat influential ($M$ = 2.867, $SD$ = 0.997) in their commitment to teach in a high-need school. From this, it appeared most of the Scholars had decided to teach in a high-need school prior to accepting the scholarship; however, when the time came to accept a job in a high-need school, the scholarship seemed to have more of an influence.

Table 11. Results for Questions from the Summer Surveys Regarding How the Scholarship Money Influenced the Scholars

| | Sum '15 | Sum '16 | Sum '17 | Summary 3 Years |
|---|---|---|---|---|
| How influential was the Noyce Scholarship money in your commitment to become a teacher? | | | | |
| Very influential | 2 (7%) | 1 (3%) | 3 (11%) | 6 (7%) |
| Somewhat Influential | 4 (14%) | 8 (30%) | 4 (15%) | 16 (19%) |
| Not very Influential | 13 (45%) | 8 (30%) | 11 (41%) | 32 (39%) |
| Not at all Influential | 10 (34%) | 10 (37%) | 9 (33%) | 29 (35%) |
| Mean | 1.931 | 2.0 | 2.037 | 1.988 |
| SD | 0.884 | 0.920 | 0.98 | 0.917 |
| How influential was the Noyce Scholarship money in your commitment to complete the teacher certification program? | | | | |
| Very influential | 2 (7%) | 0 | 1 (4%) | 3 (4%) |
| Somewhat Influential | 7 (24%) | 7 (26%) | 8 (30%) | 22 (26%) |
| Not very Influential | 10 (34.5%) | 10 (37%) | 10 (36%) | 30 (36%) |
| Not at all Influential | 10 (34.5%) | 10 (37%) | 8 (30%) | 28 (34%) |
| Mean | 2.03 | 1.89 | 2.07 | 2 |
| SD | 0.944 | 0.801 | 0.874 | 0.870 |
| How influential was the Noyce Scholarship money in your commitment to take a teaching job? | | | | |
| Very influential | 4 (14%) | 2 (7%) | 2 (7%) | 8 (7%) |
| Somewhat Influential | 5 (17%) | 7 (26%) | 7 (26%) | 19 (26%) |
| Not very Influential | 10 (34.5%) | 9 (33.5%) | 10 (37%) | 29 (37%) |
| Not at all Influential | 10 (34.5%) | 9 (33.5%) | 8 (30%) | 27 (30%) |
| Mean | 2.10 | 2.07 | 2.11 | 2.10 |
| SD | 1.047 | 0.958 | 0.934 | 0.970 |

*Note*: Very Influential = 4, Somewhat Influential = 3, Not very Influential = 2, Not at all Influential = 1

The interview data support the results of the survey data. Analysis of the interview data revealed that many of the Scholars decided to teach in high-need schools prior to accepting the scholarship. Scholars made comments such as, "I took the scholarship because I had basically decided I'm going to high-need anyway," "I don't think it was really something that changed the course of where I was headed career-wise," and "Yeah, I don't know that it affected my decisions that I made. I was pretty made up on what I wanted to do." These statements represent most of the Noyce Scholars thoughts and give sufficient evidence to believe the scholarship had little influence on their decisions to teach in a high-need school.

When the time came to find a job, however, some Scholars purposefully looked for jobs

in high-need schools. Some comments made by Scholars during the interview relating to this were "Initially, I was gearing more towards high-need because I had the Noyce scholarship," "I made sure that my principal would sign the papers saying it met high-need school and all of that. So that was kind of my deciding factor. I would have probably not accepted this job if it didn't meet that criteria." and "So I knew I had to fulfill the requirement, but I had lots of options…having that scholarship really put what school you are going to teach at the forefront of your mind." Thus, the stipulations associated with the Noyce Scholarship assisted with locking them into teaching in a high-need school at a time when they could have changed their minds.

Additionally, the interview data provided an opportunity to better understand other factors that influenced the Scholars into teaching and teaching in high-need schools that are non-Noyce related. A number of different reasons surfaced from the interview data. Scholars cited non-Noyce related reasons like the desire to make a difference in the community or in students' lives, experiences they had in high-need environments, the ability to relate to high-need settings, and familiarity in high-need settings.

Without a doubt, the most common reason scholars cited throughout the interviews was the desire to make a difference in the community or in students' lives. Many Scholars expressed this as the number one reason they decided to teach and to teach in a high-need school. Scholars made comments such as, "Really the need is in lower income areas. That's where high-quality instruction is needed and people who really understand the material. And so I wanted to be the person for the lower income – for higher need schools," "I wanted to try to bring good education into a place where maybe there hasn't been some, or maybe people don't believe in the students as much, or maybe they don't get as many opportunities.", and "I think it goes back to I just feel passionately that every child deserves a quality education." One participant cited a high-impact

learning experience as her main reason for teaching high-need students. Here is how she described her experience: "It actually goes back to an organization that I was in at the university called Students Reaching Out. We worked with 8th graders that were in a high-need area and we talked to them about scholarships and going to college and I just fell in love with the students." Scholars felt that working in the high-need environment made a larger impact on society because the need was greater; they felt they provided opportunities to children where opportunity typically does not exist.

Some Scholars said they chose to teach in high-need schools because they felt they could relate to students in high-need settings. Some stated they were from a high-need setting themselves and thus the challenges, disadvantages, and home life were familiar to them; they had gone through some of the same struggles as disadvantaged students. These Scholars shared stories about their personal experiences and then noted that it was those experiences that motivated them to teach in high-need settings. In these stories the Scholars detailed their personal struggles and explained their desire to be an inspiration for students who were experiencing similar situations. One Scholar said, "I will tell you that I grew up in a single parent home. So that was very familiar to me. Just wanting to give to my community was the way that I was brought up. To be in a single family home; it was what gave the desire to me, that desire to give to kids that weren't as fortunate as others." Another Scholar openly discussed her personal background: "Neither one of my parents graduated from college and then I was also an orphan by the time I was 11 and I was in a foster home. Basically I was a high-need kid. I didn't have a lot of help at home and by the time I was in high school I was also working full time to support myself and my brothers. I didn't have very good high school teachers and it seemed like maybe I could help someone else that was in that position since I had dealt with it.

That's kind of why I chose high-need." Some of the other Scholars noted things such as, "I came from a high-need background too" or "I guess it was because I was a high-need kids myself, and I think those kids a lot of times need help because of their family situation or their family background." Having these type of personal connections and relations to high-need students can have a positive impact on the students because they may feel like the teacher can better understand their personal situation; it may give the teacher more creditability in the eyes of the students.

For some participants, it did not matter if the school was high-need or not; the school was an opportunity to work or to work in a certain region. Scholars made comments such as, "I just happened to apply to certain schools in that area. Going in, I didn't know whether it was high-need or not. It just turned out that it happened to be high-need." Other comments were "It wasn't necessarily that I set out to find all of the high-need school districts. Those were just the ones that I wanted to be at more, so I think it was more anticipating ending up at a high-need school district than as an obligation.", "Honestly it would have been hard to be hired first coming out of school that wasn't high-need.", and "Probably because that's where all the jobs were open around here." Depending on the regions of Texas in which the student wanted to teach, the high-need requirement might not have been criteria they needed to tend to because of the vast number of high-need schools in some areas.

Personal reasons were also given as factors for choosing to teach in high-need settings. The Scholars identified things like location of the school, familiarity with the area, or family reasons. One Scholar stated: "That was mainly to move back to my hometown. It was more of a family issue I guess. The school was a good fit, and that location fit my family's needs and things. As for being high-need, that was a part of it, but not the main reason for deciding where I

was going to go." Another Scholar echoed the same sentiments "This is the same school I came from and the area I'd like to be in. It was just a good fit." Finally, family reasons were also cited as factors as noted by one Scholar: "That was where my husband was. I got married right before I started student teaching and he had a house there……it was more about finding a job than it was finding a high-need job." Working in areas where Scholars have family ties or previous experiences is one of the factors that play a role in the Scholars' decision-making process for employment.

**Influences on Retention in High-Need Schools**

On the summer surveys, Scholars reported the level of influence the scholarship had on their intent to remain in a high-need school. For this, Scholars answered two questions. The first was "How influential was the Noyce Scholarship money in your commitment to remain in a high-need school for the full term of your commitment?". On average, across the three years, Scholars reported that the Noyce Scholarship money somewhat influenced their commitment to remain in a high-need school for the full term of their commitment ($M$ = 3.05, $SD$ = 0.987). The second question was "How influential was the Noyce Scholarship money in your commitment to remain teaching in a high-need school beyond the full term of your commitment?". On average, across the three years, Scholars reported that the Noyce Scholarship was not very influential in remaining in a high-need school beyond the full term of their commitment ($M$ = 2.277, $SD$ = 0.995). Thus, it appears that the Noyce Program helped to keep the Scholars in high-need schools for the length of their commitment, but not beyond.

The interview data was somewhat mixed and did not fully support this notion. In the interviews, some Scholars noted they intended to remain in high-need schools for the term of their commitment but some seemed skeptical to commit beyond the terms of their obligation.

This deduction comes from comments such as, “I’ll remain for at least three more years.”, “Probably for at least four to five more years.”, and “My overall long-term goal is to stay at that (high-need) campus until my youngest daughter gets out of fifth grade.” Other Scholars, however, reported they planned to continue to work in a high-need school beyond their commitment. Comments such as, “I don’t see myself getting out of a Title 1 school,” “It’s very possible I will continue to teach in high-need schools for the foreseeable future,” and “I can see myself teaching in it for the rest of my life,” were comments given by some Scholars. Thus, it seems that for some Scholars, the commitment to high-need schools was a long-term commitment; for others the commitment did not seem as strong.

The interview data also allowed us to better understand some of the factors involved in retaining the Scholars in high-need settings. Scholars provided reasons for why they intended to stay in the high-need setting and also gave indications of what could potentially make them leave the high-need setting. Scholars cited reasons like school context, personal reasons, standardized testing, autonomy, job burnout, and apathetic students as factors that would make them leave or stay in high-need schools. By far, the most frequent reason given for leaving or staying in high-need settings was school context.

Scholars routinely cited administration as the single important factor in determining whether they stayed in a high-need school or not. The work environment and colleagues were also commonly referred to, but not nearly as much as administrative support. Comments made by the Scholars were “The only reason why I would need to leave is if we’re not getting the support from the administration that we need to do our job,” “I guess as long as I am treated fairly by the administration I will continue,” “Honestly probably if our administration changed…I might leave,” “The leadership at our schools…I’ve been fortunate to work with some awesome leaders

on our campuses and currently I just adore our principal," "The biggest reason is the people I work with. Kids are kids, no matter what school you're at," and "One of the reasons I left the school was because there was absolutely no communication, there was just no respect." The adults that the Scholars worked with appeared to have a much larger influence on their persistence in high-need schools than the children they taught; supportive administrative and collegial relations seem to play a very large role in teacher retention in high-need settings.

Personal factors were also reasons frequently given by Scholars for leaving or staying in high-need settings, but not nearly as frequent as school context. There were a variety of personal reasons that Scholars cited. "My wife and I are feeling a call to full-time ministry in another country," "If my husband later on wanted to move to another area with another school that pays well," "The main reason I ended up leaving my old school was just because the distance of where we lived and I had a second child," "Money plays a great deal in to it, because I work a lot harder than I think the money is worth." and "Hopefully I might start a family soon." Because personal reasons are particular to the individual Scholar, it may be difficult for external factors, like school context, to influence their decisions to stay in high-need schools.

There were other reasons stated for possible reasons for leaving high-need schools. Miscellaneous comments that Scholars made were, "I honestly think that the factors that would push me out of it would maybe just be wanting to be surrounded by students who want to learn, and who are not being pushed to learn," "I was tired of the administrative part of it and then having to deal more with standardized testing than actual math teaching. I was burnt out after six years, I was just tired." and "I have pretty good freedom to do what I want, I'm the lead of my department, so I'm in a leadership role here and I don't necessarily foresee myself leaving." A few Scholars were indifferent and made comments such as, "I can't think of anything that would

take me away." Thus, apathetic students, standardized testing, autonomy, and job burn out were also reasons cited for leaving high-need schools, but these reasons were ones less frequently cited.

**Other Impacts or Influences of Noyce Program**

Analysis of the interview data and the open-ended questions from the summer surveys revealed a variety of other impacts the Noyce Program had on the Scholars that were not related to high-need schools. These impacts were classified into three main themes: (1) financial aspects, (2) improved emotional well-being, and (3) professional development and networking. At times, these themes overlapped or one may have caused an effect on the other. The relief of financial burden on a student, for example, may improve a student's emotional well-being because the stress involved with finding money to pay for college may have been reduced. Nonetheless, the three themes were prevalent within the coded data and yielded some interesting results and unanticipated outcomes of the Noyce Program.

**Financial Aspects**

The money the Scholars received impacted them both as undergraduates and as in-service teachers. As undergraduates, the main overarching theme that surfaced during data analysis was the relief of financial burden. Scholars noted that the money from the scholarship improved their financial situation as undergraduates, but the way in which their financial situation improved and the repercussions from this improvement varied. For some scholars, the relief of financial burden came from not having to work while in school, for others it was the fact they did not have to take out additional student loans while in college, and yet for others it was a way for them to finish their degrees quicker. However the Scholars were relieved of the financial burden, all of them expressed it as a major impact of the Noyce Program.

In both the open-ended survey questions and the interviews, Scholars frequently commented that the money from the Noyce Scholarship eliminated their need to work part-time jobs. This freed up some of their time and allowed them to focus more on their academics and maintain their success as a STEM student. The exchange in time working a part-time job with time for studying was attributed to the Noyce Program. Comments from Scholars were, "It did help a lot because by the time I received the scholarship I was already a mom and I had 2 kids and my husband was the only one working. It really did help a lot with me not having to get a part-time job," "I did not have to take a part-time job during my final year of classes and my student teaching," and "It helped me decide to quit my part-time job in college."

Another positive outcome of not having to work a part-time job was that students could finish their undergraduate degrees faster. Not having to work allowed Scholars to enroll in more classes and consequently obtain a Bachelor's degree in less time than it would have without the scholarship. One Scholar commented, "It would have taken me longer to get my degree because I probably would have had to get a part-time job and probably take fewer credit hours so it would take me a bit longer. Also, the money helped during student teaching because basically that is a full-time job." The opportunity to not work while in college impacted the Scholars in many different ways, all of which helped them be more studious students.

There were three other reported outcomes from individual Scholars. For one Scholar, who decided later in her college career to become a teacher, the scholarship money helped cover the additional tuition fees incurred by taking the required education classes. This Scholar said, "I guess it was more of a relief of financial burden because I was starting so late I had to add more courses, which made my tuition amount go up." The other Scholar commented on how the reduction in student loan debt as an undergraduate allowed her to seek a master's degree

immediately after graduation. This Scholar said, "If I had not gotten the Noyce Scholarship, I would have a ton more debt and I probably wouldn't have continued on to get my master's degree. I continued on to get my master's degree knowing that eventually my undergrad would be paid off, and so I think that if I didn't have that additional money, I probably would've been hesitant to add more debt." Finally, one Scholar was able to save money while in college. This Scholar said, "When I left college, I probably saved up about $10,000 to $12,000 that I didn't use throughout the process…I'm proud of the fact that I made some really good choices and not be financially irresponsible. I was able to use a lot of money I saved after the fact, and that helped me out." The reflections of the Scholars after they had been in the teaching field for a few years revealed a more mature perspective. As more seasoned adults, the Scholars seemed to better assess how financial decisions made in their younger years impacted various aspects of their later years.

As in-service teachers, the participants' main overarching theme was a reduction in student loans. Scholars shared how the reduction in student loans has a positive effect on their financial decisions after graduation. Because of lower student loan payments, some Scholars willingly took lower paying jobs. This was indicated by the comments "I was able to take a lower paying job in order to live in the same town as my fiancé," and "I was able to teach in a district with slightly lower salary opportunity." Another Scholar indicated the money helped financially in the months after graduating but before the first paycheck. This Scholar's comment was, "It helped bridge the gap after graduation until my first paycheck in September." There were some other individual comments made by Scholars relating to how the money affected them after graduation. They referred to things like the ability to purchase supplies for their classrooms, gaining experience before pursuing a master's degree, and experiencing positive

parental support after college. Comments indicating this were, "Because my parents didn't have to pay for my school as much, thanks to the Noyce scholarship money, they were able to help me a little bit more when I graduated and started out, finding a house and things like that," and "There was a brief period in time, my first couple of years teaching, that I did think about going back to school for a master's degree in higher education…but ultimately I didn't want to do that because I wanted to fulfill the requirements for the scholarship. I'm glad that I didn't pursue my master's degree earlier because then I ended up going back and getting my master's in administration and not higher education." Not having to pay back large amounts of student loan debt has positively impacted the Scholars in many unforeseen ways and given the relatively low salaries of teachers, any financial perks they can gain is advantageous.

**Improved Emotional Well-Being**

Another overarching theme that surfaced in the data analysis was the improved emotional well-being of the Scholars. Some of the Scholar's improved sense of emotional well-being was a consequence of other themes, such as the improved financial status, but the comments relating to this were so frequent and stated so emphatically that it seemed necessary have it as a stand-alone theme. Comments within this theme related to feelings the Scholars had as a consequence of the Noyce Program. In the summer surveys and the interviews, Scholars referred to an improved sense of emotional well-being through comments that related to (a) relief of stress, (b) feeling more valued and appreciated, (c) having higher levels of motivation, (d) improved relationships with parents, and (e) closer connection with the Noyce advisers. All of these factors contributed to an improved sense of emotional well-being for the Scholars. Evidence that Scholars had an improved sense of emotional well-being came from comments such as, "It (the Noyce Program) sparked more of an excitement to work harder and to do better. It made me feel like someone

finally appreciated that I'm working hard," "Really the main benefit to me was peace of mind," "I know that it made the monetary aspect and worrying about the financial burden a lot more doable and a lot less scary." and "It was the main reason my dad didn't have to pay for college." Raising the esteem of the Noyce Scholars and helping to make them feel more valued is an outcome that is not readily achieved in the education profession and is a highlight for the Noyce Program.

The Noyce Program also had university personnel dedicated to overseeing and interacting with the Scholars as both undergraduates and as in-service teachers. Many Scholars noted the special support they received as undergraduates from their university advisers in the Noyce Program. Scholars stated, " I just felt like it was more attention. I always had someone to talk to that knew me personally," "I felt like advisers were always very supportive of the Scholars. They checked in with us more maybe than other students." and "There were extra advisory meetings and there were definitely people in the Noyce Program available to help answer questions and troubleshoot things." One Scholar commented on the support he received as an in-service teacher. His comment was, "Our Noyce Program would send out surveys and stuff to see how we were doing and provided us with options to help." From these comments, it seems that supporting high-achieving students during their undergraduate years, as well in their induction years, provides some of the emotional support necessary to help them be successful.

**Professional Development and Networking**

In both the summer surveys and the interview data, Scholars discussed opportunities the Noyce Program provided for professional development and networking. These opportunities occurred as both undergraduates and as in-service teachers. Some Scholars reported they were able to attend national-level conferences such as the National Science Teacher Association

(NSTA) Conference, the American Educational Research Association (AERA) Annual Conference, and the Noyce Annual Conference. Other Scholars attended state-level conferences designed specifically for teachers of mathematics or science, and yet others reported the opportunity to attend smaller professional development institutes such as AP Physics or Calculus. Encouraging Noyce Scholars to attend conferences and other institutes seemed to introduce the Scholars to many of the professional opportunities available in teaching and can positively influence their perceptions of teaching as a long-term career.

Attending these conferences and networking with other teachers passionate about STEM teaching seemed to have a very positive impact on the Scholars. Evidence of this is in the comments from Scholars: "The Noyce Program sent me to those conferences and, again, that was just absolutely the best thing that could have happened; going to the conferences and actually seeing other teachers, especially teachers that care," "Yes, actually I was able to attend the STEM Summit. It's more for the engineering department, but it's a big conference held all weekend. I got to go to that because I was a Noyce Scholar. That helped me a lot," "I have traveled to a science conference every year that I have taught. I would not have been able to do that if not for the Noyce scholarship. I learned valuable information at those conferences," "I was given funding (and continue to receive funding) to attend AP Physics Institutes which allowed me to expand my content knowledge, interact with other physics teachers, and give me the credibility to be a higher-level physics teacher." and "The Noyce Program has supported me by offering to pay for local and state conferences that my school would be unable to pay for." Statements by the Scholars align with position statements from the NSTA and the National Council for Teachers of Mathematics (NCTM) regarding the importance of professional development to produce high-quality STEM teachers strong in content and pedagogy.

Another positive impact of the program was networking with other Scholars and teachers. Scholars reported this as one of the most valued opportunities. Scholars recalled opportunities to network with other Scholars at banquets hosted by the university's Noyce Program as well as the conferences and seminars. Comments made by the Scholars were "I got to really, really network and hear other people's stories and just get a wide variety and a more varied look at what I was about to get started and get into. And I feel like that was really helpful and it was because of the Noyce Program," "We all got to see each other and talk to each other. It was nice because some of the people that were in the Noyce Program I still know them today. We don't talk all the time, but we still keep in contact every now and then." and "Seminars and networking opportunities were some of the many perks of the scholarship." Networking with others who have similar professional goals helps develop community, connect experiences, and provides a space to share ideas and learn from others. Having these opportunities as undergraduates or novice teachers helps to break the barrios of isolation that many new teachers experience during their induction years.

**Program Improvement Suggestions**

In the summer surveys Scholars were given the opportunity to offer suggestions for improving the experience in the Noyce Program. The analysis of this data yielded three main suggestions for future programs: a) more emphasis on teaching in high-need environments, (b) more support while in the first few years of teaching, and (c) other suggestions.

Scholars most frequently commented on the need for more training on topics relating to teaching in high-need environments. Many Scholars suggested the need for extended, frequent, and immersive work in multiple schools that are considered high-need. This includes working in both urban and rural schools that serve students with low-income families. Scholars' comments

were, “Programs need to better prepare them to teach in a high-need school; a broader experience is required of students during their student teaching,” “There should be a class on how to teach high-need students in the math and science classroom. High-need students are different in the fact that they have many things happening at home that conflict with school. They are very different in the math and science classrooms because many of them have grown up in communities that do not value math and science. Many have uneducated parents who fear mathematics.”, and “Pre-service teachers talking to teachers that are teaching in high-need schools is necessary to really let them know what it is like. It is not as scary as it seems from the outside and actually is so much more fulfilling.” One Scholar suggested that Noyce Programs emphasize the “need” part of the high-need student. He wanted programs to focus on what “high-need” means and what that looks like in the classroom. He said “Sometimes the label ‘high-need’ makes people think high-need is in the inner-city, crime ridden areas when that is not always true; for me, it was a rural community with a high percentage of free and reduced lunch and a high teacher turnover.” Immersive experiences in high-need settings as an undergraduate may help to create a more well-developed skill set for handling the unique challenges of high-need settings.

The second suggestion made by many Scholars was to provide support while in the first few years of teaching. Most of the suggestions related to providing mentorship during the first few years of teaching and following up with Scholars once they start teaching. Suggestions that Scholars made were, “Continue to talk with other Scholars about their experiences in teaching so there is continued support,” “Help with school supplies our first year of teaching,” “Continued mentorship throughout my first years of teaching would have been valued.” and “Follow-up weekends during 1$^{st}$ and 2$^{nd}$ years of teaching to share observations and ideas with program

peers." Many times, once students leave the university's teacher preparation program, they too leave the emotional and organizational support structures developed during their undergraduate years. Preventing this abrupt change by offering encouragement, support, and advise may help novice teachers more successfully persist in the teaching field.

Finally, there were three suggestions given by only a single Scholar. These comments were "Reduce the commitment to high-need schools.", "Some Spanish for talking with parents would have been really helpful." and "I would like to have taken a class on how the adolescent brain works/develops." Though these types of comments were not made by multiple Scholars, there is still some value in the thoughts and opinions of individual Scholars.

## Discussion

Results indicate the Noyce Scholarship Program did not heavily influence Scholars' decision to enter the teaching profession or to teach in a high-need school; the Scholars had made these decisions prior to entering the Noyce Program. It does seem, however, that the Noyce Program helped ensure Scholars work in a high-need school after graduation for at least the length of their obligation. Both the survey and the interview data indicated the Noyce Program did have an impact on the schools in which the Scholars chose to teach after graduation. Scholars specifically looked for schools satisfying the terms of their Noyce obligation. Thus, even though Scholars were fairly confident they want to teach in high-need schools prior to entering the program, it appears the Noyce Program is instrumental in solidifying their decision to teach in high-need schools; when the time comes to actually teach in high-need school and stay there for the length of their commitment, the Scholars felt their obligation to the Noyce Program was not negotiable.

The Noyce Program seems to have an impact on ensuring the Scholars work in high-need schools for the length of their commitment, but data on the level of influential in retaining Scholars beyond the length of their commitment was mixed. It is interesting, however, that approximately 70% of the Scholars were still teaching in high-need schools beyond the length of their commitment. It seems something, outside the Noyce Program, may influence the Scholars to remain in high-need schools beyond the terms of their Noyce obligation. One reason may be the authentic experience a high-need school provides; these experiences may validate many of the reasons the Scholars entered the profession. The interview data indicate that many Scholars entered the profession to make a difference in students' lives, the community, and to provide educational opportunities to students who have not typically had such opportunities. Based on the data, these experiences in the high-need settings appear to improve the Scholars' attitudes about the students in high-need schools and give them a sense of fulfillment. Scholars' commented, "Kids are kids no matter what school you are at." and "It is not as scary as it seems from the outside." These types of comments, and others in the data provide a glimpse into the realizations and understandings the Scholars developed while working in high-need schools. These positive attitudes and perceptions may affect the Scholars' outlook on how long they plan to work in high-need schools. Their sense of satisfaction and fulfillment of working with students in high-need schools may help retain them in a high-need school not only for the length of their commitment, but even beyond.

Though intrinsic reasons may retain Scholars beyond the terms of their commitment, so too may extrinsic reasons. The data overwhelmingly indicated that the school administration plays a large role in retaining teachers in high-need schools. Scholars identify school administration as possibly the single, most important factor in their decision to stay or leave a

high-need school; support from the administration was the most frequent reason given by many Scholars for remaining in, or leaving, high-need schools. An administration that backs up the teachers, provides the financial and emotional support teachers need to do their job, treats them fairly, and respects them as professionals is the type of administration that Scholars cited as supportive. An administration containing these characteristics seems to override many other issues (i.e., apathetic students, lack of parent involvement, and pressures of standardized testing) that may deter teachers from remaining in high-need schools.

There were other impacts of the Noyce Program that were not related to high-need settings. One was the reduction of financial burden as both an undergraduate and in-service teacher. The relief of the financial burden came in different forms; some Scholars did not have to work a part-time job, others were able to graduate on time, and yet others were able to pursue a master's degree or work in a lower paying school district. Regardless of the type of relief the Scholar experienced, the reduction of financial burden on teachers is a huge impact for both the teachers and the teaching profession. Providing teachers the opportunity to start their professional careers off on a more positive financial note is a remarkable outcome and one worth recognition. Furthermore, providing teachers the opportunity to work in schools that may be unable to offer stipends or higher salaries is a plus for the education profession.

Another effect of the Noyce Program was an improved sense of well-being for the Scholars. Lower stress levels for teachers, increasing their sense of value, and helping them have a higher sense of motivation and esteem are impacts that directly affect teachers in a positive way. Though this improved sense of well-being is connected to other factors, it is still an important impact for retaining teachers in the profession.

Many Scholars indicated the Noyce Program allowed them to attend professional development opportunities they might not have otherwise been able to attend. These opportunities came in the form of state- and national-level conferences as well as traditional professional development institutes. Providing the funds to attend these professional development opportunities not only gave Scholars the chance to learn from other expert teachers but also the opportunity to network with other Scholars and teachers who are passionate about teaching. Scholars indicated the conferences and networking opportunities were some of the most valued opportunities as both undergraduate students and in-service teachers. This aligns with position statements from national STEM teacher organizations such as NSTA and NCTM.

## Conclusion

Many of the findings in this study align with findings from other studies. This study, however, offers further understanding of additional impacts, perceptions, and attitudes of the Noyce Program. Overall the Noyce Scholars perceptions and attitudes of the Noyce Program are very positive. The impacts the program had on them personally, emotionally, and financially occurred both during their undergraduate years and in their time as a teacher. Though most of the Scholars had committed to becoming teachers in high-need schools before they were a part of the Noyce Program and were not influenced into the teaching profession by the Noyce Program, the program did provide high-need schools with high achieving STEM students and the majority of the Scholars remained teaching in high-need settings.

Findings in this study indicate previous experience with students in high-need settings, or other high-impact learning opportunities that allow college students to have an impact on students' lives, may help to recruit STEM students into the teaching profession. Providing college students, even those who have not considered teaching, with high-impact experiences

involving disadvantaged school-aged children may help college students find their passion for working in high-need schools. Offering fully- or partially-funded opportunities for college students to work in schools in unfamiliar cities with dedicated and skilled STEM teachers can expand their horizons, open their minds, and help them find the true benefits of teaching. This is something Noyce Programs and other teacher incentive programs may consider implementing.

Finally, Scholars seemed to stay in high-need schools for the length of their commitment, but were indifferent about continuing in high-need schools beyond the commitment. This, combined with the request for more support after graduation, provides reason to rethink the distribution of the program's money. It may be beneficial to offer gradual incentives to Scholars if they stay in high-need schools longer than the initial commitment. Rethinking ways to recruit and retain STEM teachers into the teaching field is important for the quality of STEM teaching and adding financial benefits may actually be cheaper for schools and programs instead of the revolving door effect that is now prevalent in secondary STEM teaching.

## Limitations

This study involved only 29 teachers and represents a very small sample of all Noyce Scholars. Additionally, the three-year duration of the study, the interviews, the classroom observations, and the commitment to complete the surveys may have deterred other eligible Noyce Scholars from the study. This subjects this study to sample bias.

# CHAPTER IV

# IMPACTS OF NOYCE SCHOLARSHIP ON CLASSROOM CONTEXTS OF SECONDARY STEM TEACHERS

Classrooms are complex social systems that are multi-dimensional, dynamic, diverse, and ever-changing. They differ in a variety of areas including emotional and instructional supports, classroom organization (Hamre & Pianta, 2010; Hamre, Pianta, Burchinal, & Downer, 2010), ability levels, available technology, and overall quality of the classroom. Orchestrating such complex systems requires a well-developed craft of teaching (Leatham & Peterson, 2010) where teachers skillfully facilitate student learning by balancing the cognitive and social aspects of learning, while tending to the diverse needs and abilities of the entire learning group (Cortina, Miller, McKenzie, & Epstein, 2015). Managing all these contexts within the classroom is challenging, and the challenges are different across grade bands, especially as they relate to student engagement.

Student engagement in schools changes as the students' emotional, social, and cognitive needs develop throughout elementary and secondary school. Engagement in elementary school is generally high, but then begins to decline early in adolescence. By the time students enter high school this decline is pronounced to the point where more than half of high school students report that they do not take their schooling or their studies seriously (Marks, 2000). In secondary schools, the extent to which student are motivated and engaged by their teachers is one of the largest mediators of academic success (Fredricks, Blumenfeld, Paris, 2004; Pinata & Allen, 2008; Ready, Edley, & Snow, 2002). More importantly, secondary school is a time when students' interactions with teachers are critical to their academic and personal successes, but it

comes at a time when teacher-student interactions are frequently of poor quality (Resnick, et al, 1997; Roeser, Eccles, & Sameroff, 2000). Oftentimes this result is attributed to a failure to capitalize on student interests, goals, and motivation, a situation which tends to lead to disengagement and alienation (Pianta, Hamre, & Allen, 2012). Disengagement in the classroom is related to low academic achievement, disruptive and uncooperative behavior, and missed instructional time, a combination which eventually can lead to school failure (Fredricks et al., 2004; Laffey, 1982; Spivack & Cianci, 1987). To address the declining engagement in school at any grade level, but especially at the secondary level, it is important that teachers tend to all needs of the students.

Improving the overall classroom environment can have a positive effect on the engagement of students in secondary schools. Classrooms having student–teacher interactions that promote student autonomy, structure, and cognitive stimulation conducive to students' engagement and learning are quality classrooms (Malmberg, Hagger, Burn, Mutton, & Colls, 2010). These quality classrooms bring together the three domains of (a) emotional or affective support (Pianta, Howes, et al., 2005; Pianta, La Paro, Payne, Cox, & Bradley, 2002; Skinner & Belmont, 1993; Skinner, Zimmer-Gembeck, & Connell, 1998), (b) organizational or structural support (Kunter & Baumert, 2006; Marsh, 1991; Opdenakker & Van Damme, 2006; Skinner & Belmont, 1993), and (c) an instructional or effectiveness component (den Brok, Brekelmans, & Wubbels, 2004; Hattie & Timperley, 2007; Opdenakker & Van Damme, 2006). The emotional or affective component addresses relationships between students and teachers and promotes warm, caring, and positive relationships. In this component, the teacher actively and purposively strives to build positive and appropriate relations with his or her students. The organizational or structural component includes things such as classroom management, time on task, and teacher

organization. Finally, the instructional or effectiveness component focuses on influence, cognitive stimulation, and feedback for task-dependent items. Blending all aspects of a quality classroom into a well orchestrated, positive learning environment can increase student engagement, even at the secondary level.

Studying the complex social, emotional, and cognitive structures that exist in classrooms can help teachers, administrators, teacher educators, and other stakeholders better understand the nuances of classroom quality and the craft of teaching. Classroom observation is a valuable method for investigating these situations because it allows researchers to collect detailed information about student and teacher behaviors along with environmental characteristics within natural and authentic settings (Weber, Waxman, Brown, & Kelly, 2016) and it helps reveal the complexity of events that occur within the classroom (Kane, Taylor, Tyler, & Wooton, 2011). Observational research has been used to collect data on classroom components such as teacher-student interactions (Pianta et al, 2002), instructional quality (Stuhlman & Pianta, 2009), specific teaching and learning behaviors (Waxman, Padrón, Franco-Fuenmayor, & Huang, 2009), and technology integration (Inan, Lowther, Ross, & Strahl, 2010). Many of the subtle nuances and dynamic intricacies of effective teaching that are difficult to capture in surveys and interviews can be captured successfully in classroom observations.

The instruments used in observational research differ from other data collection methods and allow the classroom context to be studied from a wider lens. Observation protocols focus on effective teaching practices (O'Leary, 2012; Taylor & Tyler, 2012) that can be reliably observed and assessed (Hamre et al., 2013) for the purpose of describing (Ross, Smith, Alberg, & Lowther, 2004) and improving teachers' instructional practices (Hill & Grossman, 2013; New Teacher Project, 2013; Ross et al., 2004). Observational data can also be triangulated with other

forms of quantitative or qualitative data to help identify specific teaching practices that lead to positive student outcomes such as student engagement (Raphael, Pressley, & Hohan, 2008; Ross et al., 2004) and academic achievement (Kane et al., 2011). In addition to data triangulation, researchers can integrate multiple observation instruments into a single observation, a process which allows for investigation of several aspects of the classroom context and supplies a rich, multi-dimensional conceptualization of classroom dynamics (Hilberg, Waxman, & Tharp, 2004; Waxman et al., 2009). Studying classroom contexts through multiple observational methods, with or without triangulation, provides opportunities for deeper understanding of student learning and engagement as well as of the behaviors, interactions, and instructional practices that occur in the classroom.

The purpose of this study was to use observational methods to investigate classroom contexts of a specific group of teachers. Researchers wanted to capture the teacher-student interactions, student and teacher behaviors, teachers' instructional strategies, and other classroom contexts of teachers who received the Robert Noyce Teaching Scholarship from a university in the South Central region of Texas. The Robert Noyce Teacher Scholarship Program (Noyce Program) is a U.S. Government initiative (sponsored by the National Science Foundation) that was enacted to address the critical need of teachers in high-need fields, specifically the high-need fields of science, technology, engineering, and mathematics (STEM). The Noyce Program encourages talented STEM students to pursue teaching careers in mathematics and science by providing institutions of higher education funding to recruit "individuals with strong STEM backgrounds who might otherwise not have considered a career in K-12 teaching" (National Science Foundation, 2012, p. 7). The program was designed to increase the number of STEM teachers with strong STEM content knowledge to teach in high-need school districts. STEM students who

are awarded the scholarship receive substantial funds – sometimes as much as $20,000 ($5000 per semester for their junior and senior years) – and usually participate in special opportunities in these high-need school settings. As part of their scholarship, recipients are required to complete one year of teaching in a high-need public school district for each semester of financial support. If scholarship recipients do not fulfill the teaching commitment, they must pay back the funds in the form of an interest-bearing loan. To date, the Noyce Program has produced 10,196 new STEM teachers and 638 Master Teachers who either are teaching or have taught in high-need school districts throughout the country (S. Richardson, personal communication, July 24, 2017). This suggests that high achieving STEM students are taking advantage of opportunities presented to them, but the actual impact the Noyce Program has had on classroom instruction and other classroom contexts remains unstudied.

Some research does exist on the impacts of scholarship programs on recipients' decisions to become a teacher, or to teach in low-income schools. The dollar amounts awarded by the programs have been found to have an impact on scholarship recipients' decisions; their decisions were influenced more when the financial incentive covered a higher proportion of their tuition (Darling-Hammond, 2007; Henry, Bastian, & Smith, 2012; Liou & Lawrenz, 2011). For the Noyce Teaching Scholarship specifically, there is evidence that the financial incentive did not influence the scholars' decisions to enter the teaching profession; many of the Noyce Scholars would have entered the teaching profession regardless of the financial incentive (Bull, Marks, & Salyer, 1994; Liou, Desjardins, & Lawrenz, 2010). For those Noyce Scholars who might not have otherwise considered a career in teaching, however, the financial incentive did have a larger impact on their decisions to enter the teaching profession (Liou & Lawrenz, 2011). Competitive scholarships appear to attract individuals with significantly higher academic credentials and

higher levels of human capital into teaching, but unless the scholarship programs require recipients to work in high-need schools, they tend to teach in schools and classrooms with more high-achieving students from higher-income families. (Henry et al., 2012). The financial incentive offered by the Noyce Scholarship had the most influence on recruiting teachers to high-need schools and completing their certification program, but less of an influence on staying in a high-need school for long periods of time (Liou, Desjardins, & Lawrenz, 2010; Liou, Kirchhoff, & Lawrenz, 2010; Liou & Lawrenz, 2011). Though some research has been done, there is scant research on whether these programs help solve the teacher shortage problem. Furthermore, there is little evidence suggesting these scholarship programs are increasing the quality of instruction in the classroom. Further research is necessary to help understand the classroom contexts of scholarship recipients. Thus, the research questions guiding this study are:

1. How do Noyce Scholars' classrooms or teaching behaviors compare to those of the non-Noyce Scholars?
2. How do Noyce Scholars' students' behaviors compare to those of the non-Noyce Scholars?
3. How do Noyce Scholars' overall classroom environments compare to those of non-Noyce Scholars?

## Methods

### Design

For this study, we used a quasi-experimental design and applied stratified matched sampling to compare the teaching behaviors, student behaviors, and the overall classroom environments of participants who received a Noyce scholarship to those participants who did not. Targeted participants were classroom teachers who received their secondary mathematics or

science teaching certification through the same secondary undergraduate teacher preparation program. Data for this study were generated from five classroom observations that were conducted over five academic semesters: Spring 2015, Fall 2015, Spring 2016, Fall 2016, and Spring 2017.

**Participants**

Participants eligible for this study were teachers who obtained secondary mathematics or science teacher certification from the same teacher preparation program from 2002 to 2014. The program was an undergraduate secondary teacher preparation program at a large, research university located in the South Central region of Texas. Students in the program all obtained a bachelor's degree in a mathematics- or science-related field, took at least 18 hours of education courses, observed in secondary schools for at least 120 hours, and completed either a 12-week student teaching experience or a one-year internship. All students who successfully completed program requirements received Texas mathematics or science teaching certification for grades 7 (or 8) through 12.

From 2002-2007, and again from 2009-2014, the preparation program received two Robert Noyce Teaching Scholarship Grants. These grants provided funds for the program to award high-achieving STEM students a scholarship to use toward their undergraduate college expenses. Each student was a mathematics or science major with at least a 3.0 average and was committed to teaching upon graduation. Throughout the 10 years of institutional funding, 71 students were awarded the scholarship and hence selected as Noyce Scholars. Each of the Noyce Scholars received $5,000 per semester for a minimum of one and a maximum of four semesters and agreed to teach in a high-need school district for one year. If the teaching agreement was not

fulfilled, the Noyce Scholar was required to pay back the scholarship funds as an interest-bearing loan.

At the time of this study, 61 of the 71 Noyce Scholars were employed in the education profession and thus were eligible to participate in the study. Of the 10 ineligible, one was in graduate school, six no longer had valid teaching certificates, one was teaching out of the state, and no contact information was found for the remaining two. Email messages were sent to all 61 eligible scholars inviting them to participate with a stipend of $675. Fifteen did not respond (of those, 6 messages bounced back), 19 declined to participate in the study, and 29 agreed to participate in the study.

Study participants also included a selected control group of teachers who did not receive a Noyce Scholarship but were certified through the same teacher preparation. At the time of participant selection, there were 178 eligible participants (referred to as non-Noyce Scholars). An email message was distributed in Fall 2014 describing the terms of the study, which included information about the stipend of $675. Three rounds of email messages were sent to the control group; 130 did not respond (including 9 messages that bounced back), 9 declined to participate in the study, and 39 agreed to participate in the study.

The 39 non-Noyce Scholars who agreed to participate in the study were stratified on two items–school locale code and years of experience in the education profession–and matched to the 29 selected Noyce Scholars. The school locale code (National Center for Educational Statistics, 2006) classifies schools based on its proximity to an urbanized area. The years of teaching experience were examined and matched, as closely as possible, to the school locale code and number of years of teaching experience of the Noyce Scholars. This process resulted in the omission of seven non-Noyce Scholars and created a sample size of 29 (Noyce Scholars) and 32

(non-Noyce Scholars). Because this study focuses on the environmental characteristics in classrooms as well as student and teacher behaviors within the classroom, only those participants who were classroom teachers were included in the study. Of the 29 Noyce Scholars, 22 were classroom teachers and of the 32 Non-Noyce Scholars, 29 were classroom teachers. Thus, for this study, 22 Noyce Scholars and 29 non-Noyce Scholars were selected as final participants. Demographics for the 51 participants are displayed in Table 12.

Table 12. Demographics of Study Participants for Each Group

| | Noyce | | Non-Noyce | | |
|---|---|---|---|---|---|
| | Male ($n$ = 7) | Female ($n$ = 15) | Male ($n$ = 5) | Female ($n$ = 24) | Total |
| Subject | | | | | |
| Mathematics | 4 | 9 | 4 | 13 | 30 |
| Science | 3 | 6 | 1 | 10 | 20 |
| English | 0 | 0 | 0 | 1 | 1 |
| Ethnicity | | | | | |
| White, Non-Hispanic | 6 | 14 | 4 | 21 | 45 |
| Hispanic | 0 | 1 | 1 | 1 | 3 |
| Asian or Pacific Islander | 1 | 0 | 0 | 1 | 2 |
| Other | 0 | 0 | 0 | 1 | 1 |
| School Locale | | | | | |
| City | 2 | 3 | 4 | 7 | 16 |
| Rural | 4 | 2 | 1 | 5 | 12 |
| Suburb | 0 | 9 | 0 | 8 | 17 |
| Town | 1 | 1 | 0 | 4 | 6 |
| Years Teaching Experience | | | | | |
| 0-2 | 2 | 4 | 2 | 11 | 19 |
| 3-5 | 3 | 6 | 3 | 6 | 18 |
| 6-8 | 1 | 2 | 0 | 2 | 5 |
| > 8 | 1 | 3 | 0 | 5 | 9 |

Throughout the three-years of the study, the number of participants observed in each group fluctuated. Eighteen of the 22 Noyce Scholars were observed all five times. Two of the Scholars were not observed the first time because one was out on maternity leave and the other had taken off the 2014-2015 school year for personal reasons. These two Noyce Scholars were observed during the other four observations. In year two, one Noyce Scholar dropped from the

study and thus was not observed in year two or three. In year three, one more Noyce Scholar dropped from the study and was not observed in year three. This type of fluctuation is a result of life events happening over the three-year study. In a three-year longitudinal study, some fluctuation is expected. It is common for teachers to move schools, switch courses, or accept an administrative position; the participants in this study are no exception. Though there was fluctuation in the study that affected data collection, all but two of the participants were observed three or more times. This at least provides repeated measures over time and protects somewhat against out of norm data. So, though there was fluctuation with regard to number of observations, the fact there were still multiple observations on the majority of participants helps guard against skewed data.

Table 13. Tracking of Participants and When Each was Observed Throughout the Three Years

| | Year 1 | Year 2 | | Year 3 | | |
|---|---|---|---|---|---|---|
| Observation # | 1 | 2 | 3 | 4 | 5 | |
| Noyce Scholars | | | | | | Reason for Missed Observation |
| #1-18 | Yes | Yes | Yes | Yes | Yes | n/a |
| #19 | No | Yes | Yes | Yes | Yes | Maternity Leave |
| #20 | No | Yes | Yes | Yes | Yes | Not Teaching, Personal Reasons |
| #21 | Yes | No | No | No | No | Quit Teaching |
| #22 | Yes | Yes | Yes | No | No | Quit Teaching |
| Total Obs. | 20 | 21 | 21 | 20 | 20 | |
| Non-Noyce Scholars | | | | | | Reason for Missed Observation |
| #1-22 | Yes | Yes | Yes | Yes | Yes | n/a |
| #23 | No | Yes | Yes | Yes | Yes | Finishing Grad School |
| #24 | Yes | No | No | No | No | Became a School Counselor |
| #25 | Yes | No | No | Yes | Yes | Special Education Co-Teacher for Yr. 2 |
| #26 | Yes | Yes | Yes | No | No | Quit Teaching, Had a Baby |
| #27 | Yes | Yes | Yes | No | No | Quit Teaching |
| #28 | Yes | Yes | Yes | No | No | Quit Teaching |
| #29 | Yes | Yes | Yes | No | No | Became a School Principal |
| Total Obs. | 28 | 27 | 27 | 24 | 24 | |

Twenty-two of the 29 non-Noyce Scholars were observed all five times. One non-Noyce Scholar was not observed during the first observation because she was finishing graduate school; she was observed during the other four observations. In year two, one of the non-Noyce Scholars became a special education teacher and was not a traditional classroom teacher, so she was not observed in year two, but was observed in years one and three. Also in year two, one of the non-Noyce Scholars became a school counselor. Thus, she was not observed in year two or three. In year three, four non-Noyce Scholars were not observed because three of them quit teaching and one became a school principal. A description of which participants were observed during each observation period is displayed in Table 13.

**Instrumentation**

Three instruments were used during each observation and each was adapted from instruments used in previous research studies. The instruments were a mix of low- and high-inference observations. The low-inference instruments used systematic observation methods that provide specific and easily identifiable behaviors easy for observers to code (Waxman, 2003). The high-inference instrument required observers to make a judgment based on a series of classroom constructs such as, "Teacher provided opportunities for students to be creative." The combination of instrument types helped collect information in a variety of forms and provided quantitative methods of data collection.

**Student observation schedule.** The Student Observation Schedule (SOS) was adapted from the Student Behavior Observation Schedule (Waxman, Wang, Lindvall, & Anderson, 1988) and was designed to capture information on students' classroom behaviors, interactions, and levels of engagement with the teacher and the academic content. The SOS is a low-inference, systematic observation instrument used to record the observed information during ongoing

classroom instruction and learning. During each observation, three individual students were observed with reference to (a) the setting in which the student's behaviors and interactions occurred; (b) whether the student was on- or off-task; (c) whether the student engaged in the lesson behaviorally, cognitively, or emotionally; (d) the type of interaction the student had with other students, teachers, or other support staff; (e) the type of activity, or activities, in which the student participated; (f) the types of technology the student used to engage in the academic content; and (g) the educational purpose for the technology that was used.

For each observation, three students were randomly selected based upon proximity to the observer. During the student selection process, which occurred within the first few minutes of the visit, observers selected students who they could see clearly without obstruction; this helped guarantee all behaviors and interactions could be appropriately observed. When possible, they tried to choose at least one male and one female and diversify by race; but this was not always possible. Throughout the class period, each student was observed for six to ten cycles of 30-second. During the cycles, the observer watched the students in a sequence (i.e., student 1, student 2, student 3) to help ensure the time elapsed between observations was as somewhat consistent. At the end of each 30-second cycle, the observer marked the behaviors or interactions that occurred within the cycle. When the class period was over, relative frequencies were calculated and recorded as a percentage of occurrences for each item on the SOS for each student.

**Teacher observation schedule.** The Teacher Observation Schedule (TOS) was adapted from the Teacher Roles Observation Schedule (Waxman, Wang, Lindvall, & Anderson, 1990) and the Classroom Observation Measure (Ross & Smith, 1996). The TOS is a low-inference, systematic observation instrument designed to capture information on teacher interactions,

behaviors, and instructional techniques during the ongoing classroom instruction and learning. During the observation teachers were observed with reference to (a) interactions with students; (b) instructional setting in which the observed behavior occurred; (c) whether the instruction was of direct, seatwork, or learner-centered orientation; (d) the nature of the interaction; (e) the purpose of the interaction; and (f) instructional use of technology.

The TOS was implemented concurrently with the SOS. Throughout the class period the observer watched the teacher for a total of six to ten cycles of 30-seconds, but the six to ten cycles were dispersed throughout the SOS cycles. Thus, the series of observations was: (a) observe student 1 for 30 seconds and mark observations, (b) observe student 2 for 30 seconds and mark observations, (c) observe student 3 for 30 seconds and mark observations, and (d) observe the teacher for 30 seconds and mark the observations. When the class period was over, relative frequencies were calculated and recorded as a percentage of occurrences for each item on the TOS.

**Overall classroom observation schedule.** The Overall Classroom Observation Schedule (OCOS) was adapted from the Classroom Observation Measure (COM) (Ross & Smith, 1996) and was designed to capture instructional behaviors of teachers and students, the overall classroom environment, and the overall perception of various forms of technology used during instruction by the teachers. The OCOS is a high-inference instrument used to examine (a) behaviors used by the teacher during instruction; (b) behaviors displayed by the students during instruction; (c) the types of technology used by the teacher during the lesson; (d) the teacher's intended use of the various technologies used during the lesson; and (e) the educational purpose for the student's use of technology.

The OCOS was completed at the end of the class visitation for each category. For the OCOS, observers rated the general frequency of behavioral items they observed on a 3-point scale (no instances, once or twice, three or more times). For example, observers recorded whether the behavior "Teacher acted as a coach/facilitator" was observed zero times, once or twice, or more than twice.

**Procedures**

In early Spring 2015, five observers located across different regions of Texas, were convened at a high school near the university for a face-to-face training on all observation instruments. Observers were debriefed on the observation instruments and given a training manual to make notes on and refer to throughout the five-semester data collection process. In the debrief session, the researcher emphasized the SOS and TOS were systematic observations to be completed throughout the visit and the OCOS was a high-inference instrument to be completed at the end of the observation. During the training, the five observers completed a total of three observations. The mean inter-rater agreement across all trained observers was 94% for the SOS, 92% for the TOS, and 77% for the OCOS.

At the beginning of each semester, starting Spring 2015 and ending Spring 2017, the trained observers were provided with a list of the participants to observe. The list was stratified by proximity to the observer to minimize the distance required to travel. Each observer was paid a stipend of $100 per completed observation and was reimbursed the travel costs incurred with each observation. Due to movement of teachers from year-to-year, the list of participants assigned to each observer changed slightly each school year; only four (7.8%) of the 51 participants had two or more observers throughout the three years of the study. Each observer was responsible for contacting the participant to schedule the observation.

Data for each of the five observations were coded in a spreadsheet and averaged across the five observations for each participant. Data from the spreadsheet were imported into the Statistical Package for the Social Sciences (SPSS) for analysis. Descriptive statistics were calculated for each of the five observations and for the average of the five observations. The averaged data were used to report demographics along with the behaviors, interactions, and activities most frequently used by both groups. Independent samples *t*-tests were calculated on all observations and the overall averaged data to identify any statistically significant differences between the groups' teaching, student behaviors, and overall classroom environments.

## Results

Across the five semesters of the study, a total of 236 observations were conducted. In Spring 2015, for the first observation, 20 Noyce Scholars and 28 non-Noyce Scholars were observed. For the second and third observations (Fall 2015, Spring 2016), 21 Noyce Scholars and 28 non-Noyce Scholars were observed. For the fourth and fifth observations (Fall 2016, Spring 2017), 20 Noyce Scholars and 24 non-Noyce Scholars were observed. Descriptive statistics and independent samples *t*-tests were calculated for each of the five observations. In addition, an average value was calculated across the five observations for the SOS, TOS, and OCOS for all participants. Descriptive statistics and independent samples *t*-test were also calculated for the average of the observations. At least one statistically significant difference between groups was found in all five observations as well as the average of the observations.

### Teacher Behaviors and Interactions

The TOS was a systematic observation instrument that had 51 items the observer could mark as an observed setting, interaction, behavior, or instructional strategy. These 51 items were grouped into six sections: (a) Interactions, (b) Setting, (c) Instructional Orientation, (d) Nature of

Interaction, (e) Purpose of Interaction, and (f) Instructional Technology. In the data analysis, researchers looked only at the average across the five observations to determine items that occurred most frequently within these sections for both the Noyce and non-Noyce Scholars. The descriptive statistics for the average of all observations of the two groups are displayed in Table 14.

Table 14. Descriptive Statistics for Average of Observations on the TOS

| | Noyce | | | Non-Noyce | | |
|---|---|---|---|---|---|---|
| | Rank | Mean | SD | Rank | Mean | SD |
| Interaction | | | | | | |
| With student(s) (instructional) | 1 | 0.79 | 0.18 | 1 | 0.72 | 0.20 |
| With student(s) (managerial) | 2 | 0.07 | 0.07 | 2 | 0.09 | 0.06 |
| With student(s) (collaborative) | 3 | 0.06 | 0.09 | 3 | 0.08 | 0.13 |
| No interaction | 4 | 0.04 | 0.07 | 4 | 0.06 | 0.08 |
| Other (Specify): | 4 | 0.04 | 0.06 | 5 | 0.03 | 0.09 |
| With student(s) (social, personal) | 6 | 0.01 | 0.01 | 6 | 0.02 | 0.05 |
| Setting | | | | | | |
| Whole class | 1 | 0.58 | 0.24 | 1 | 0.58 | 0.20 |
| Traveling | 2 | 0.20 | 0.14 | 2 | 0.20 | 0.16 |
| Small group | 3 | 0.10 | 0.12 | 4 | 0.07 | 0.09 |
| Individual | 4 | 0.08 | 0.13 | 3 | 0.10 | 0.14 |
| Dyads | 5 | 0.03 | 0.05 | 6 | 0.03 | 0.06 |
| Other (Specify): | 6 | 0.02 | 0.03 | 5 | 0.04 | 0.07 |
| Instructional Orientation | | | | | | |
| Direct instruction | 1 | 0.53 | 0.24 | 1 | 0.53 | 0.19 |
| Seatwork | 2 | 0.25 | 0.18 | 2 | 0.28 | 0.17 |
| Learner-centered | 3 | 0.18 | 0.23 | 3 | 0.13 | 0.18 |
| Other (Specify)**:** | 4 | 0.03 | 0.05 | 4 | 0.05 | 0.10 |
| Nature of Interaction | | | | | | |
| Explaining | 1 | 0.73 | 0.13 | 1 | 0.65 | 0.17 |
| Cueing or prompting | 2 | 0.50 | 0.18 | 2 | 0.45 | 0.21 |
| Modeling | 3 | 0.28 | 0.23 | 3 | 0.22 | 0.20 |
| Questioning | 4 | 0.26 | 0.21 | 4 | 0.21 | 0.17 |
| Positive commenting | 5 | 0.16 | 0.16 | 5 | 0.13 | 0.15 |
| Demonstrating | 6 | 0.14 | 0.15 | 8 | 0.06 | 0.09 |
| Listening | 7 | 0.10 | 0.09 | 6 | 0.12 | 0.15 |
| Other (Specify)**:** | 8 | 0.07 | 0.07 | 7 | 0.08 | 0.09 |
| Neutral commenting | 9 | 0.02 | 0.03 | 9 | 0.03 | 0.04 |
| Negative commenting | 10 | 0.01 | 0.04 | -- | 0.00 | 0.01 |
| Purpose of Interaction | | | | | | |
| Focus on process | 1 | 0.51 | 0.28 | 1 | 0.48 | 0.30 |
| Focus on content | 2 | 0.48 | 0.26 | 2 | 0.35 | 0.27 |
| Focus on outcome | 3 | 0.26 | 0.20 | 3 | 0.19 | 0.18 |
| Assess prior knowledge | 4 | 0.24 | 0.24 | 4 | 0.14 | 0.17 |
| Assess new knowledge | 5 | 0.23 | 0.25 | 5 | 0.10 | 0.16 |
| Encourage students to succeed | 6 | 0.12 | 0.15 | 6 | 0.09 | 0.10 |
| Encourage extended student responses | 7 | 0.11 | 0.11 | 6 | 0.09 | 0.11 |
| Shows interest in student work | 8 | 0.09 | 0.09 | 8 | 0.12 | 0.16 |

Table 14. Continued

| | Noyce | | | Non-Noyce | | |
|---|---|---|---|---|---|---|
| | Rank | Mean | SD | Rank | Mean | SD |
| Connect content to real life issues | 8 | 0.09 | 0.09 | 10 | 0.07 | 0.12 |
| Redirect student thinking | 10 | 0.08 | 0.08 | 11 | 0.08 | 0.08 |
| Praise student performance | 10 | 0.08 | 0.10 | 12 | 0.06 | 0.06 |
| Correct student behavior | 10 | 0.08 | 0.09 | 12 | 0.06 | 0.07 |
| Show personal regard for student | 13 | 0.06 | 0.08 | 14 | 0.07 | 0.08 |
| Encourage students to help each other | 14 | 0.05 | 0.06 | 15 | 0.04 | 0.05 |
| Encourage student self-management | 14 | 0.05 | 0.07 | 16 | 0.03 | 0.05 |
| Praise student behavior*)* | 14 | 0.05 | 0.08 | 16 | 0.03 | 0.06 |
| Correct student performance | 14 | 0.05 | 0.05 | 16 | 0.03 | 0.05 |
| Other**:** | 14 | 0.05 | 0.09 | 9 | 0.10 | 0.20 |
| Encourage students to question | 19 | 0.03 | 0.05 | 16 | 0.03 | 0.04 |
| Connect content to other disciplines | 20 | 0.02 | 0.04 | 20 | 0.02 | 0.03 |
| Instructional Technology | | | | | | |
| Use technology to present material | 1 | 0.65 | 0.25 | 1 | 0.58 | 0.23 |
| Use technology to create product | 2 | 0.09 | 0.15 | 3 | 0.04 | 0.09 |
| Assist students with technology | 3 | 0.08 | 0.12 | 2 | 0.05 | 0.08 |
| Use technology to access the Internet | 4 | 0.03 | 0.09 | 4 | 0.02 | 0.04 |
| Use technology as a communication tool with others outside the classroom | -- | 0.00 | 0.01 | -- | 0.00 | 0.01 |

In the Noyce Scholars' classrooms, the most predominant setting observed was whole class instruction (58%), followed by traveling (20%) where the teacher goes from one student to the next, and finally, small group instruction (10%) and individual work (8%). In these settings, direct instruction took place about 53% of the time, students participated in seatwork 25% of the time, instruction was learner centered 18% of the time, and 3% of the time another form of instructional orientation occurred. The teachers mostly interacted with their students in an instructional context (79%). Other contexts less frequent were managerial (7%), collaboratively (6%), no interaction or other interaction (4%) and socially (1%). The nature of these interactions most often involved explanation (73%), cueing or prompting (50%), and modeling (28%) or questioning (26%), where the purpose of the interaction was focusing on process (51%), content (48%), or outcome (26%) to access prior (24%) or new (23%) knowledge. Instructional technology was used most frequently (65%) to present material.

In the non-Noyce Scholars classrooms, the predominant setting observed was whole class instruction (58%), followed by traveling (20%), and finally, individual work (10%) and small group instruction (7%). In these settings, direct instruction took place about 53% of the time, students participated in seatwork 28% of the time, instruction was learner centered 13% of the time, and 5% of the time another form of instructional orientation occurred. The teachers mostly interacted with their students in an instructional context (72%). Other contexts less frequent were managerial (9%), collaboratively (8%), no interaction (6%) or other interaction (3%), and socially (2%). The nature of these interactions most often involved explanation (65%), cueing or prompting (45%), and modeling (22%) or questioning (21%), where the purpose of the interaction was focusing on process (48%), content (35%), or outcome (19%), or showing interest in student work (12%). Most of the time (58%) instructional technology was used to present material.

The independent samples *t*-test results revealed significant differences between groups in Interaction, Setting, Nature of Interaction, and Purpose of Interaction. The significant differences occurred in observations #1, #2, #5, and the average of the TOS data. The statistically significant results revealed by the *t*-tests for the TOS, and the observation in which each statistically significant result occurred, are displayed in Table 15. The Noyce Scholars were observed significantly more often to be (a) explaining, (b) demonstrating, (c) focusing on new knowledge, and (d) assessing new knowledge. Conversely, the non-Noyce Scholars were observed (a) interacting with students in a managerial way, (b) using other instructional settings, and (c) using other reasons for the nature of interactions.

Table 15. Descriptive Statistics and Independent Samples T-test for all Statistically Significant Results

| | | Noyce | | | Non-Noyce | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Items from TOS | Obs. # | *n* | M | SD | *n* | M | SD | *t* | *df* |
| Interaction | | | | | | | | | |
| With student(s) (managerial) | 2 | 21 | 0.06 | 0.07 | 28 | 0.13 | 0.14 | 2.28* | 41.35 |
| Setting | | | | | | | | | |
| Other | 1 | 20 | 0 | 0 | 28 | 0.06 | 0.14 | 2.07* | 27 |
| Nature of Interaction | | | | | | | | | |
| Explaining | 1 | 20 | 0.72 | 0.15 | 28 | 0.58 | 0.28 | 2.22* | 42.73 |
| Demonstrating | 5 | 20 | 0.19 | 0.27 | 24 | 0.05 | 0.13 | 2.09* | 26.34 |
| | Avg | 22 | 0.14 | 0.15 | 29 | 0.06 | 0.09 | 2.34* | 32.39 |
| Other | 1 | 20 | 0.04 | 0.06 | 28 | 0.15 | 0.24 | 2.31* | 31.33 |
| Purpose of Interaction | | | | | | | | | |
| Focus on outcome | 1 | 20 | 0.30 | 0.28 | 28 | 0.13 | 0.19 | 2.40* | 46 |
| Assess new knowledge | Avg | 22 | 0.23 | 0.25 | 29 | 0.10 | 0.16 | 2.08* | 33.35 |

*$p < 0.05$, **$p < 0.01$

**Student Behaviors and Interactions**

The SOS was a systematic observation instrument that had 43 items the observers marked as an observed setting, interaction, or activity. The 43 items were grouped into seven sections: (a) Setting, (b) Manner, (c) Types of Engagement, (d) Interaction, (e) Activity Types, (f) Educational use of Technology, and (g) Technology Type. In the data analysis, researchers looked only at the average of all five observations to determine item that occurred most frequently within these sections for both the Noyce and non-Noyce Scholars. The descriptive statistics for the average of all observations of the two groups are displayed in Table 16.

Table 16. Descriptive Statistics for Average of Observations on the SOS for Noyce and Non-Noyce Scholars

| | Noyce | | | Non-Noyce | | |
|---|---|---|---|---|---|---|
| | Rank | Mean | SD | Rank | Mean | SD |
| Setting | | | | | | |
| Whole class | 1 | 0.61 | 0.26 | 1 | 0.60 | 0.18 |
| Individual | 2 | 0.20 | 0.20 | 2 | 0.23 | 0.15 |
| Small group | 3 | 0.13 | 0.18 | 3 | 0.11 | 0.14 |
| Dyad | 4 | 0.06 | 0.08 | 4 | 0.05 | 0.07 |
| Other: | -- | 0.00 | 0.00 | 5 | 0.01 | 0.02 |
| Manner | | | | | | |
| On-task | 1 | 0.97 | 0.04 | 1 | 0.96 | 0.06 |
| Blatantly Off-task | 2 | 0.03 | 0.03 | 2 | 0.04 | 0.06 |
| Types of Engagement | | | | | | |
| Behavioral | 1 | 0.74 | 0.22 | 1 | 0.77 | 0.17 |
| Cognitive | 2 | 0.28 | 0.21 | 2 | 0.27 | 0.15 |
| Affective | 3 | 0.03 | 0.03 | 3 | 0.04 | 0.06 |
| Interaction | | | | | | |
| With teacher – instructional | 1 | 0.52 | 0.22 | 1 | 0.51 | 0.16 |
| No interaction | 2 | 0.25 | 0.13 | 2 | 0.26 | 0.11 |
| With other students | 3 | 0.21 | 0.19 | 3 | 0.20 | 0.14 |
| With teacher – managerial/social | 4 | 0.02 | 0.02 | 4 | 0.03 | 0.03 |
| Other: | 5 | 0.01 | 0.02 | 5 | 0.01 | 0.01 |
| Activity Types | | | | | | |
| Written assignment | 1 | 0.66 | 0.20 | 1 | 0.66 | 0.24 |
| Listening/watching | 2 | 0.47 | 0.22 | 2 | 0.48 | 0.14 |
| Answering teacher-posed question(s) relating to lesson | 3 | 0.16 | 0.14 | 3 | 0.11 | 0.11 |
| Using concrete learning materials | 4 | 0.15 | 0.21 | 5 | 0.10 | 0.13 |
| Exploration/inquiry | 5 | 0.12 | 0.16 | 5 | 0.10 | 0.14 |
| Discussing | 6 | 0.10 | 0.12 | 3 | 0.11 | 0.09 |
| Questioning | 7 | 0.06 | 0.04 | 10 | 0.03 | 0.03 |
| Distracted | 8 | 0.05 | 0.05 | 8 | 0.05 | 0.07 |
| No activity/transition | 9 | 0.04 | 0.03 | 7 | 0.06 | 0.04 |
| Answering peer-posed question(s) relating to lesson | 9 | 0.04 | 0.05 | 12 | 0.02 | 0.03 |
| Reading | 9 | 0.04 | 0.06 | 10 | 0.03 | 0.04 |
| Summative assessment | 9 | 0.04 | 0.06 | 12 | 0.02 | 0.03 |
| Other: | 13 | 0.03 | 0.05 | 9 | 0.04 | 0.06 |
| Tutoring | 14 | 0.02 | 0.05 | 14 | 0.01 | 0.03 |
| Working kinesthetically | 15 | 0.01 | 0.05 | -- | 0.00 | 0.02 |
| Presenting | 15 | 0.01 | 0.01 | 14 | 0.01 | 0.02 |
| Acting-out (behavior) | -- | 0.00 | 0.01 | -- | 0.00 | 0.01 |
| Education Use of Technology | | | | | | |
| Basic skills/drill/practice | 1 | 0.20 | 0.22 | 1 | 0.26 | 0.26 |
| Organizing, managing, or analyzing information | 2 | 0.03 | 0.06 | 3 | 0.03 | 0.09 |
| Gather information | 3 | 0.02 | 0.03 | 2 | 0.05 | 0.10 |
| Other: | 4 | 0.01 | 0.01 | 4 | 0.02 | 0.03 |
| Communicating and displaying findings | -- | 0.00 | 0.01 | 5 | 0.01 | 0.04 |
| Word Processing | -- | 0.00 | 0.01 | -- | 0.00 | 0.01 |
| Technology | | | | | | |
| Other 1 | 1 | 0.16 | 0.17 | 1 | 0.21 | 0.15 |
| Laptop computer | 2 | 0.04 | 0.07 | 2 | 0.05 | 0.12 |
| Desktop computer | 3 | 0.03 | 0.12 | 3 | 0.04 | 0.08 |
| Interactive whiteboard | 4 | 0.01 | 0.03 | 3 | 0.04 | 0.10 |
| Other 2 | 4 | 0.01 | 0.02 | 4 | 0.01 | 0.03 |

In the Noyce Scholars' classrooms, the most predominant setting observed was whole class instruction (61%), followed by individual (20%), and finally small group instruction (13%) and dyad (6%). In these settings, students interacted with their teachers in an instructional context (52%), had no interaction (25%), or were interacting with other students (21%). The most prevalent activity that students were observed doing was written assignments (66%). The next most prevalent activities were listening or watching (47%), answering teacher posed questions (16%), and using concrete learning materials (15%). Students were observed being on-task 97% of the time and they were engaged behaviorally (74%) or cognitively (28%). Other types of technology, usually calculators, were most frequently used (16%) and technology was used predominately for basic skill, drill, or practice (20%).

For the non-Noyce Scholars the most predominant setting observed was whole class instruction (60%), followed by individual work (23%), and finally small group instruction (11%) and dyad (5%). In these settings, students interacted with their teachers in an instructional context (51%), had no interaction (26%), or were interacting with other students (20%). The most prevalent activity that students were observed doing was written assignments (66%). The next most prevalent activities were listening or watching (48%), answering teacher posed questions or discussing (11%), and using concrete learning materials or exploring (10%). Students were observed being on-task 96% of the time and they were engaged behaviorally (77%) or cognitively (27%). Other types of technology, usually calculators, were most frequently used (21%) and technology was used predominately for basic skill, drill, or practice (26%).

The statistically significant results revealed by the *t*-tests for the TOS, and the observation in which each statistically significant result occurred, are displayed in Table 17.

Students from the Noyce Scholars classes were observed significantly more often asking questions related to the lesson. Students from the non-Noyce Scholars classes were observed significantly more often interacting with the teachers in a managerial or social context. It is important to note the low mean values for these items signifying the event did not occur very often.

Table 17. Statistically Significant Results from Independent Samples t-Test on all SOS

| | | Noyce | | | Non-Noyce | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Items from SOS | Obs. # | *n* | M | SD | *n* | M | SD | *t* | *df* |
| Interaction | | | | | | | | | |
| With teacher – managerial/social | 2 | 21 | 0.01 | 0.02 | 28 | 0.05 | 0.06 | 3.40** | 33.08 |
| Activity Type | | | | | | | | | |
| Questioning | Avg. | 22 | 0.06 | 0.04 | 29 | 0.03 | 0.03 | 2.32* | 49 |

*$p < 0.05$, **$p < 0.01$

**Overall Classroom Observation Schedule**

The OCOS was a high-inference observation instrument that had 65 items for the observer to rate immediately following the observation. The OCOS had five sections: (a) Teacher Instructional Behaviors, (b) Students' Instructional Behaviors, (c) Types of Technology, (d) Teacher use of Technology, and (e) Student use of Technology. Results from teacher and student instructional behaviors sections of the OCOS are displayed in Table 18. Results from the technology sections of the OCOS are displayed in Table 19.

Overall, the instructional behavior ratings of the Noyce Scholars' classrooms were high. In the Noyce Scholars' classrooms, the instructional behaviors of the teachers observed most frequently were having warm, supportive relationships with students (1.99/2), constructing a classroom environment that supported risk-taking (1.98/2), providing adequate feedback to

students (1.96/2), providing ample wait-time for student responses (1.95/2), facilitating students' engagement in activities and lessons to encourage participation (1.93/2), connecting ideas, concepts, and activities (1.85/2) and assisting students to organize thinking (1.84/2). The most regularly occurring student instructional behaviors were displaying positive affect toward the teacher (1.98/2), displayed positive engagement with peers (1.83/2), engaging in classroom activities (1.81/2), assuming responsibility for learning activities (1.76/2), and students doing independent seatwork (1.32/2). For technology in the classroom, the Noyce Scholars predominantly used document readers or projectors (0.84/2), interactive whiteboards (0.64/2), and handheld devises such as calculators (0.58/2). Technology was used to display material (1.48/2), integrate technology into lessons (1.38/2), and to create lessons (1.36/2). Students in the Noyce Scholars' classes used technology to learn basic skills (0.69/2) and do independent inquiry or research (0.46/2). The overall ratings for the Noyce Scholars' student use of technology were low.

Table 18. Results from Teacher and Student Instructional Behaviors Sections of the OCOS

| | Noyce | | | Non-Noyce | | |
|---|---|---|---|---|---|---|
| | Rank | Mean | SD | Rank | Mean | SD |
| Teacher Instructional Behavior | | | | | | |
| Teacher appeared to have warm, supportive relationships with students. | 1 | 1.99 | 0.04 | 1 | 1.99 | 0.07 |
| Teacher built a classroom environment that supported risk-taking. | 2 | 1.98 | 0.09 | 4 | 1.90 | 0.25 |
| Teacher provided adequate feedback to students. | 3 | 1.96 | 0.10 | 3 | 1.91 | 0.15 |
| Teacher provided ample wait-time for student responses. | 4 | 1.95 | 0.15 | 2 | 1.92 | 0.18 |
| Teacher actively facilitated students' engagement in activities and lessons to encourage participation. | 5 | 1.93 | 0.16 | 6 | 1.80 | 0.40 |
| Teacher connected ideas, concepts, and activities. | 6 | 1.85 | 0.22 | 10 | 1.74 | 0.29 |
| Teacher assisted students to organize thinking. | 7 | 1.84 | 0.25 | 8 | 1.75 | 0.31 |
| Teacher monitored/checked student work. | 8 | 1.84 | 0.33 | 5 | 1.83 | 0.27 |
| Teacher linked concepts and activities to previous learning. | 9 | 1.83 | 0.25 | 9 | 1.75 | 0.40 |
| Teacher offered encouragement of students' efforts that increased students' involvement and persistence. | 10 | 1.73 | 0.37 | 13 | 1.50 | 0.51 |
| Teacher initiated/started experiences, discussions, and activities. | 11 | 1.72 | 0.41 | 7 | 1.78 | 0.39 |
| Teacher used 3 or more forms of concurrent sensory modalities | 12 | 1.72 | 0.37 | 11 | 1.68 | 0.29 |
| Teacher provided direct instruction for the entire class. | 13 | 1.55 | 0.45 | 12 | 1.66 | 0.43 |
| Teacher acted as coach/facilitator. | 14 | 1.50 | 0.54 | 14 | 1.28 | 0.61 |
| Teacher provided students opportunities for unguided problem solving. | 15 | 1.37 | 0.69 | 15 | 1.18 | 0.69 |
| Teacher asked open-ended questions. | 16 | 1.19 | 0.72 | 18 | 0.83 | 0.66 |
| Teacher let students to develop concepts or procedures on their own. | 17 | 1.17 | 0.69 | 19 | 0.78 | 0.70 |
| Teacher integrated assessment into instructional cycle. | 18 | 1.11 | 0.52 | 17 | 0.87 | 0.47 |
| Teacher encouraged students to learn from other students' questions and comments. | 19 | 1.10 | 0.65 | 16 | 0.90 | 0.66 |
| Teacher provided opportunities for students to be creative and/or generate their own ideas and/or products. | 20 | 0.95 | 0.74 | 20 | 0.74 | 0.70 |
| Teacher provided opportunities for students to assume responsibility for learning. | 21 | 0.76 | 0.54 | 21 | 0.65 | 0.66 |
| Teacher related concepts to students' actual lives (or real world concepts). | 22 | 0.60 | 0.45 | 22 | 0.55 | 0.52 |
| Teacher displayed negative affect toward students. | 23 | 0.14 | 0.43 | 24 | 0.02 | 0.08 |
| Teacher varied styles of conversation and participation to include students' cultural preferences. | 24 | 0.02 | 0.07 | 23 | 0.09 | 0.17 |
| Students' Instructional Behaviors | | | | | | |
| Students displayed positive affect toward teacher | 1 | 1.98 | 0.11 | 1 | 1.99 | 0.04 |
| Students displayed positive engagement with peers | 2 | 1.83 | 0.26 | 2 | 1.83 | 0.20 |
| Students were engaged in classroom activities | 3 | 1.81 | 0.38 | 3 | 1.79 | 0.32 |
| Students assumed responsibility for learning activities | 4 | 1.76 | 0.36 | 4 | 1.59 | 0.42 |
| Students did independent seatwork | 5 | 1.32 | 0.30 | 5 | 1.37 | 0.46 |
| Students utilized different ways to answer problems | 6 | 1.22 | 0.64 | 7 | 0.95 | 0.61 |
| Students worked with other students in small groups | 7 | 1.01 | 0.57 | 6 | 0.98 | 0.57 |
| Students' activities were learner-centered | 8 | 0.98 | 0.72 | 9 | 0.70 | 0.73 |
| Students solved problems using real objects in the classroom environment | 9 | 0.73 | 0.72 | 8 | 0.75 | 0.53 |
| Students displayed disruptive behavior | 10 | 0.41 | 0.43 | 10 | 0.38 | 0.43 |
| Students displayed negative affect toward teacher | 11 | 0.02 | 0.09 | 11 | 0.01 | 0.05 |

Table 19. Results from Technology Sections of the OCOS

| | Noyce | | | Non-Noyce | | |
|---|---|---|---|---|---|---|
| | Rank | Mean | SD | Rank | Mean | SD |
| Technology | | | | | | |
| Document reader or Document projector | 1 | 0.84 | 0.71 | 1 | 0.86 | 0.58 |
| Interactive whiteboard/SMART Board | 2 | 0.64 | 0.68 | 4 | 0.62 | 0.63 |
| Handheld game/device/calculator | 3 | 0.58 | 0.65 | 2 | 0.71 | 0.60 |
| Desktop computer | 4 | 0.57 | 0.55 | 3 | 0.66 | 0.51 |
| Laptop computer | 5 | 0.52 | 0.61 | 5 | 0.55 | 0.61 |
| Other #1 (*e.g. ipads, clickers, etc.)*: | 6 | 0.25 | 0.28 | 6 | 0.28 | 0.31 |
| Overhead projector (traditional) | 7 | 0.05 | 0.12 | 11 | 0.01 | 0.07 |
| Other #2 | 8 | 0.04 | 0.10 | 7 | 0.11 | 0.38 |
| Television | 9 | 0.02 | 0.09 | 9 | 0.02 | 0.08 |
| MP3 player/iPod | 10 | 0.01 | 0.04 | 8 | 0.04 | 0.16 |
| Skype/video communication | 11 | 0.01 | 0.04 | -- | 0.00 | 0.00 |
| Flip camera/video camera | -- | 0.00 | 0.00 | 10 | 0.02 | 0.09 |
| Digital camera | -- | 0.00 | 0.00 | 12 | 0.01 | 0.07 |
| DVDs/CDs | -- | 0.00 | -- | -- | 0.00 | -- |
| Tape player/radio | -- | 0.00 | -- | -- | 0.00 | -- |
| Teacher use of Technology | | | | | | |
| Teacher used technology to display material/assignment | 1 | 1.48 | 0.56 | 1 | 1.48 | 0.44 |
| Teacher integrated technology into lesson | 2 | 1.38 | 0.63 | 2 | 1.44 | 0.47 |
| Teacher used technology to create lessons | 3 | 1.36 | 0.60 | 3 | 1.40 | 0.44 |
| Teacher assisted students with technology | 4 | 0.62 | 0.60 | 4 | 0.57 | 0.41 |
| Teacher used technology to assess/correct assignment | 5 | 0.30 | 0.42 | 6 | 0.25 | 0.35 |
| Teacher used technology to access the Internet | 6 | 0.29 | 0.39 | 7 | 0.18 | 0.27 |
| Teacher used technology for a non-instructional purpose | 7 | 0.27 | 0.24 | 5 | 0.30 | 0.27 |
| Teacher used technology as a communication tool | 8 | 0.14 | 0.24 | 8 | 0.17 | 0.24 |
| Student use of Technology | | | | | | |
| Students used technology to learn basic skills | 1 | 0.69 | 0.69 | 1 | 0.95 | 0.64 |
| Students used technology for independent inquiry/research | 2 | 0.46 | 0.64 | 2 | 0.48 | 0.59 |
| Students used technology for assessment purposes | 3 | 0.27 | 0.35 | 5 | 0.21 | 0.30 |
| Students used technology to enhance problem solving/creativity | 4 | 0.26 | 0.40 | 3 | 0.22 | 0.29 |
| Students used technology to access the Internet | 5 | 0.22 | 0.38 | 4 | 0.21 | 0.31 |
| Students used technology for word processing | 6 | 0.04 | 0.12 | 6 | 0.08 | 0.18 |
| Students used technology as a communication tool | 7 | 0.03 | 0.11 | 7 | 0.01 | 0.04 |

Overall, the instructional behavior ratings of the non-Noyce Scholars' classrooms were high, but generally were not as high as the Noyce Scholars. In the non-Noyce Scholars' classrooms, the instructional behaviors of the teachers observed most frequently were having warm, supportive relationships with students (1.99/2), providing ample wait-time for student responses (1.92/2), providing adequate feedback to students (1.91/2), constructing a classroom environment that supported risk-taking (1.9/2), monitoring or checking student work (1.83/2),

facilitating students' engagement in activities to encourage participation (1.8/2), and initiate discussions or activities (1.78/2). The most regularly occurring student instructional behaviors were displaying positive affect toward the teacher (1.99/2), displaying positive engagement with peers (1.83/2), engaging in classroom activities (1.79/2), assuming responsibility for learning activities (1.59/2), and students doing independent seatwork (1.37/2). For technology in the classroom, the non-Noyce Scholars predominantly used document readers or projectors (0.86/2), handheld devises (calculators) (0.71/2), desktop computers (0.66/2), and interactive whiteboards (0.62/2). Technology was used to display material (1.48/2), integrate technology into lessons (1.44/2), and to create lessons (1.40/2). Students in the Noyce Scholars' classes used technology to learn basic skills (0.95/2) and do independent inquiry or research (0.48/2). The overall ratings for the non-Noyce Scholars' student use of technology were low.

The independent samples *t*-test results revealed significant differences between groups in 12 items on the OCOS that spanned all five sections of the observation instrument. The significant differences occurred in observations #1, #2, #3, #4, and the overall average of the OCOS. These statistically significant results, along with the observation in which the each significant difference occurred are displayed in Table 20. Teachers from the Noyce Scholar group were rated as significantly more often leading students to develop concepts or procedures on their own, asking open-ended questions, integrating assessment into the instructional cycle, encouraging students to learn from other students' questions and comments, offering encouragement to students' efforts that increased students' involvement and persistence, using learner-centered student activities, and using technology to access the internet. The non-Noyce Scholars, on the other hand, were rated as significantly more often varying styles of conversation and participation to include students' cultural preferences, using handheld

game/devise/calculators, integrating technology into the lesson and students were using technology for word processing.

Table 20. Statistically Significant Results from Independent Samples t-Test on all OCOS

| | | Noyce | | | Non-Noyce | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Obs. # | *n* | M | SD | *n* | M | SD | *t* | *df* |
| Teacher Instructional Behavior | | | | | | | | | |
| Teacher let students to develop concepts | 1 | 20 | 1.25 | 0.91 | 28 | 0.61 | 0.88 | 2.47* | 46 |
| or procedures on their own. | 2 | 21 | 1.38 | 0.80 | 28 | 0.74 | 0.86 | 2.63* | 46 |
| Teacher asked open-ended questions. | 2 | 21 | 1.24 | 0.89 | 28 | 0.63 | 0.79 | 2.50* | 46 |
| Teacher integrated assessment into instructional cycle. | 2 | 21 | 1.29 | 0.90 | 28 | 0.74 | 0.90 | 2.08* | 46 |
| Teacher encouraged students to learn from other students' questions and comments. | 2 | 21 | 1.24 | 0.83 | 28 | 0.67 | 0.68 | 2.62* | 46 |
| Teacher varied styles of conversation and participation to include students' cultural preferences. | Avg | 22 | 0.02 | 0.07 | 29 | 0.09 | 0.17 | 2.19* | 39.24 |
| Teacher offered encouragement of students' efforts that increased students' involvement and persistence. | 3 | 21 | 1.90 | 0.30 | 27 | 1.52 | 0.64 | 2.76** | 38.71 |
| Students' Instructional Behaviors | | | | | | | | | |
| Students' activities were learner-centered | 2 | 21 | 1.19 | 0.93 | 28 | 0.61 | 0.83 | 2.31* | 47 |
| Technology | | | | | | | | | |
| Handheld game/device/calculator | 2 | 21 | 0.20 | 0.62 | 28 | 0.75 | 0.97 | 2.40* | 45.51 |
| Teacher Use of Technology | | | | | | | | | |
| Teacher integrated technology into lesson | 2 | 21 | 1.19 | 0.93 | 28 | 1.69 | 0.68 | 2.07* | 35.7 |
| Teacher used technology to access the Internet | 4 | 20 | 0.50 | 0.76 | 24 | 0.08 | 0.41 | 2.20* | 27.89 |
| Student Use of Technology | | | | | | | | | |
| Students used technology for word processing | 1 | 20 | 0 | 0 | 28 | 0.25 | 0.65 | 2.05* | 27 |

*$p < 0.05$, **$p < 0.01$

## Discussion

The teacher-student interactions that take place in classrooms are important for student engagement. Classroom contexts having teacher-student interactions that promote autonomy, structure, affective or emotional support, and cognitive stimulation are quality classrooms that have potential for high levels of engagement (Malmberg et al., 2010). The 51 STEM teachers in

this study exhibited some aspects of quality classrooms that contain higher-levels of student engagement and other aspects that appeared to be lacking and thus may result in lower-levels of engagement. Furthermore, the differences between the two groups revealed significant differences in some of the behaviors and interactions that have an impact on classroom context.

**Teacher Behaviors, Interactions, and Instructional Techniques**

Overall, across the five observations, the teaching behaviors, interactions, and instructional techniques between the two groups were very similar. Most of the teachers in the study interacted with students in an instructional manner with the intent of explaining processes or concepts while in a whole-class setting using direct instruction. Teachers from both groups mostly used technology to present material. Thus, in comparing the most frequent teaching behaviors, interactions, and instructional techniques, there seem to be no large differences between the Noyce and the non-Noyce Scholars.

For specific observations, there were some significant differences between the groups, particularly in observation #1. In the first observation, the non-Noyce Scholars used an alternative setting significantly more than the Noyce Scholars, but the mean frequency of this occurrence was small (6%). Further review of the observation data revealed the "other setting" for this observation was primarily settings where the teacher was sitting at his or her desk working on other tasks that did not involve interaction with the students. This would include settings where the lesson was over and students were waiting to be dismissed or when the teacher expected students to work independently without assistance. Also revealed in the analysis of observation #1 was the significant difference in the nature of interaction of the non-Noyce Scholars; they were reported to have interactions for reasons other than those listed on the observation instrument (questioning, explaining, demonstrating, etc.) significantly more than the

Noyce Scholars. Further review of the data indicated that this significant difference is related to the significant difference found in the setting category. Because the teachers were engaged in tasks that did not involve interactions with students, this affected the nature of the interaction simply because there was no interaction. The last significant difference, for observation #1, indicated that Noyce Scholars were observed explaining and focusing on outcomes significantly more frequently than the non-Noyce Scholars. Thus, it seems that in observation #1, the Noyce Scholars were focusing on final answers of problems or results of a science experiment during class more than non-Noyce Scholars. Because this difference occurred only observation #1, it cannot be concluded that this is a regular difference between groups.

The other significant differences that warrant highlighting are the differences that occurred in teachers' interactions across the five observations. Analysis revealed that the Noyce Scholars were observed significantly more often using demonstration to interact with the students and the purposes for the interactions were to access new knowledge. Interactions involving demonstration include activities such as students watching the teacher perform an action, but the students not replicating the actions. For example, students could watch a science demonstration that involves mixing chemicals or a computer software demonstration that shows changes in parameters of various mathematical functions. During the observations, the observers did not make notes of the specific types of demonstrations in the study, so there is no way to determine the actual types of demonstrations that were used by the teachers. Additionally, this study did not focus on the reasons behind the differences, but because there were an equal number of mathematics and science teachers in each of the two groups, it does not seem plausible that content discipline played a role.

**Student Classroom Behaviors, Interactions, and Level of Engagement**

Overall, across the five observations, the student classroom behaviors, interactions, and level of engagement between the two groups were very similar and the significant differences that were found had low means, indicating a low relative frequency of observed occurrence. Results indicate most students were engaged in written assignments while listening, as a whole class, and while the teacher delivered instruction. Most students were doing what was expected of them, were demonstrating on-task behavior, and when technology was used by the students, it was generally a calculator for the purpose of drill, skill, or extra practice. The significant differences between groups were few, and the means were low. Analysis of the SOS data revealed that on average, across all five observations, Noyce Scholars asked questions at a higher percentage (6% compared to 3%). On observation #2 the non-Noyce Scholars were observed interacting with the students in a managerial way significantly more than the non-Noyce Scholars (5% compared to 1%). Though there was significant differences, because the frequencies on these items were so low this cannot be generalized to have a large impact on classroom instruction.

**Instructional Behaviors and Overall Classroom Environment**

The analysis of the overall classroom environment showed some differences between the two groups. In comparing the top five instructional behaviors of each teacher group, the top four behaviors were all the same, though the actual rank of the items were slightly different. For the Noyce Scholars, the item that ranked fifth was the behavior relating to the teacher offering encouragement for students' efforts that led to increased student involvement and persistence. For the non-Noyce Scholars, the fifth ranked item was the behavior relating to the teacher monitoring or checking student work. For all the top ten ranked items in the teacher behavior

group, the Noyce Scholars had a higher, or equal, mean value when compared to the non-Noyce Scholars.

For items on other sections of the OCOS, there were some differences among the ranking of items between groups. In the section for student's instructional behaviors, the ranking of the behaviors for the two groups was exactly the same. In the technology section, the top five items for each group were the same, though the ranking order differed slightly; the Noyce Students used the interactive whiteboard more frequently than the non-Noyce Scholars. Finally, the comparison of the ranking order for the use of technology shows both groups used technology for nearly the same reasons.

In analyzing significant differences between groups, it appears that observation #2 had the largest number of significant differences. For this observation, Noyce Scholars showed significantly higher means than non-Noyce in the student and teacher instructional behaviors categories. These behaviors were ones like students developing concepts on their own (also a significant difference on observation #1), learning from other students' questions, and asking open-ended questions. These behaviors seem to align with those behaviors common to student-centered classrooms. The non-Noyce Scholars, on the other hand, showed significantly higher means for items related to technology indicating they integrated technology into the classroom and used devises like calculators more frequently than the Noyce Scholars. There are a number of factors that may have played into these differences for observation #2. It could be the time of year in which the observer visited the classroom (observation #2 was conducted in a fall semester), whether there were two participants at the same school teaching similar lessons, or whether it was related to the course content. Given the nature of the observation instruments

there is no way to determine why observation #2 was so had so many statistically significant differences.

There were significant differences between groups on other individual observations as well. In observation #1 the non-Noyce Scholars students were observed using technology for word-processing significantly more often than the Noyce Scholars. In observation #3 the Noyce Scholars were observed significantly more often offering encouragement that led to increased student involvement and persistence and in observation #4 they were observed using technology to access the internet significantly more often than the non-Noyce Scholars. Finally, in the average of the all the observations, the non-Noyce Scholars were observed significantly more often varying styles of conversion and participant to include students' cultural preferences.

## Conclusion

The differences between the Noyce Scholars and the non-Noyce Scholars in this study were minimal. It appears the Noyce Scholars spent more class time demonstrating, questioning, and focusing on outcomes than the non-Noyce Scholars, but there is no way to know if this is because of their classification as a Noyce Scholar. Noyce Scholars were high-achieving students who committed to teaching in a high-need school early in their careers and this could have an impact on their teaching as well as the courses they teach. For example, sometimes STEM teachers that have the educational backgrounds like those of the Noyce Scholars teach the higher-level STEM courses in high-need schools, and sometimes they may be teaching these higher-level courses early in their careers. This could have an impact on the teacher-student interactions and the instructional techniques, as well as the teacher and student behaviors that occur in the classroom.

Overall, it appears that the classroom context of all teachers in the study were of good quality especially as it relates to emotional and organizational support. Data indicated that teachers often had positive emotional and affective support in the classroom. Teachers were perceived to have warm supportive relationships with the students, and they fostered a classroom environment that supported risk-taking. Data also indicated the teachers actively facilitated the lessons to promote student interaction and engagement and did so in a way that encouraged participation, gave feedback, and monitored student work. These are indicators that the classrooms observed were positive arenas for learning STEM content.

The area of a quality classroom that seemed to be lacking in all of the different classroom contexts was the development of autonomy. High quality classrooms should promote independent thought development, opportunities for students to assume responsibility for learning, opportunities for exploration and learning from peers, and connections to the students' lives and interests (Malmberg et al., 2010). The items on the OCOS that related to these types of concepts were scored very low for both groups. Improving upon this aspect of quality classroom contexts is an area on which Noyce Programs, and secondary teacher preparation programs in general, should focus to help improve student engagement and achievement in schools. Sometimes the emotional and organizational support that students need for successful engagement in school is easier for STEM teachers to learn and acquire from watching others teach. For some STEM teachers this may come fairly naturally. Integrating autonomy into the teaching practice, however, may not be so natural or easy and therefore must be purposefully taught during the teacher preparation phase.

## Limitations

The sample size of this study was small and this may have affected some of the results of the study. Additionally, the teachers involved in the study all agreed to have their classrooms observed for a three-year period. They may have affected the type of teachers that were recruited into the study and may not give an accurate depiction of the Noyce and non-Noyce teachers from the university's teacher preparation program.

# CHAPTER V

# SUMMARY AND CONCLUSION

Recruiting STEM students to teach high school math and science is challenging. Students with degrees in mathematics and science have a wide variety of professions they can enter; many of which are higher paying or have higher prestige than the teaching profession. Combine this with messages STEM student receive that teaching might be a less than ideal profession and the complexities become very real. Finding ways to de-emphasize the negative perceptions of teaching and highlight the benefits is part of the recruiting challenge.

Solving the STEM teacher recruitment problem requires efforts from a variety of agencies. Efforts on changing the perception of STEM teaching as a profession, increasing STEM teacher salaries, and providing a positive work environment are initiatives that can help with recruitment efforts. These efforts, however, require additional funds and cultural shifts, both of which have their own sets of challenges. Offering monetary incentives as a recruitment mechanism is an effort that can be enacted relatively quickly and with a fairly modest amount of money. Thus, the emergence of scholarship programs, such as the Robert Noyce Teaching Scholarship Program, are initiatives that have potential to have an immediate effect on the STEM teacher recruitment, and possibly retention, issues. Studying possible impacts scholarship programs have on the teaching profession can help stakeholders better understand the footprint the programs are leaving on the teaching profession and on the scholarship recipients themselves.

The purpose of this dissertation was to gain insight on some of the effects and impacts of scholarship programs on the teaching profession and on the Scholars themselves. As a starting point, researchers narrowed the focus of the studies to the Robert Noyce Teaching Scholarship

Program that was housed at a single university. The university had awarded 71 Noyce Scholarships across a 12-year period and thus had generated a sufficient number of potential participants for the study. There was also a large group of students who did not receive the Noyce Scholarship but were part of the same university's teacher preparation program. These two groups of potential study participants gave researchers the opportunity to employ a quasi-experimental design, make comparisons between groups, and gain a better understanding of the characteristics, perceptions, and experiences that may be unique to the Noyce Scholars. Identifying factors unique to Noyce Scholars can help all stakeholders in the education profession better understand how to improve secondary STEM teacher recruitment, preparation, and retention.

## Recruitment and Retention of STEM Teachers

In the first study of this dissertation, researchers learned through data analysis that Noyce Scholars made decisions about their future plans at younger ages and for reasons different than the non-Noyce Scholars. Results of this study indicated that significantly more Noyce Scholars decided to become teachers before the age of 18 than non-Noyce Scholars. This was emphasized in the second study where most Noyce Scholars reported they decided to teach prior to accepting the scholarship and thus the scholarship did not necessarily influence their decision to become a teacher. Thus, it seems reasonable to conclude the Noyce Program that was involved in this study did not recruit many STEM students who had previously not considered teaching into the teaching profession.

There is evidence, however, that a pool of STEM students who are undecided in their careers exists. This was verified when some of the non-Noyce Scholars indicated they did not decide to become a teacher until their college years. Identifying these STEM students who are

undecided on their career paths and informing them of their opportunities in the teaching profession may be a platform to increase teacher recruitment. Because positive experiences with underprivileged students seem to help recruit college students into the profession, scholarship programs may have a larger impact on the recruitment of teachers if programs offer these types of high-impact learning experiences to STEM students who are undecided on a career. A tiered structure to scholarship programs that elevate the incentives the longer the Scholars stay committed to the teaching profession may be one way to encourage more STEM students who had previously not considered teaching into the profession.

Combining high-impact learning experiences with marketing campaigns that highlight the positive aspects of the teaching profession may also prompt more STEM students to choose teaching as a career. Many of the non-Noyce Scholars indicated they choose teaching because of the nature of the profession. Significantly more non-Noyce Scholars cited conduciveness to family life and the flexibility of teaching as reasons why they chose teaching as a career. Including these types of factors in recruitment campaigns may influence more students who had not previously considered teaching into the teaching profession.

When investigating the effect of the Noyce Program on recruitment and retention into high-need schools, however, there was a positive effect. Though many of the Scholars decided to teach in high-need schools prior to accepting the scholarship, when the time came to accept a teaching job, the scholarship did influence the Scholars to take jobs in high-need schools. Though some of the Scholars may have had the opportunity to teach in school not classified as high-need, their commitment to the Noyce Program prompted them to take a job in a high-need school. These findings align with previous research (Bull, Marks, & Salyer, 1994; Liou,

Desjardins, & Lawrenz, 2010; Liou, Kirchhoff, & Lawrenz, 2010; Liou & Lawrenz, 2011) and provide information scholarship programs can use when formulating program stipulations.

School context is a factor in teacher recruitment and retention that cannot be ignored. Undoubtedly, administrative support and positive collegial relationships surfaced as two factors that influence retention in schools. Scholars frequently cited their administrators and colleagues as two factors that effect whether they would stay or leave high-need schools. To increase retention in high-need schools, or in any type of school, administrators should consider focusing on creating a positive school climate. This could have a ripple effect for recruitment of teachers as well because if teachers have a positive perception of their careers they may be more likely to encourage some of their best performing students to enter the teaching profession. Current teachers are one of the best ways to recruit new teachers into the teaching profession, but before teachers will do this, they have to have a positive outlook on the teaching profession themselves.

**Other Effects and Impact of the Noyce Program**

Overall the Noyce Scholars had positive perceptions and attitudes toward the Noyce Program. The money from the scholarship appeared to improve the Scholars' financial situations and helped the scholars in a number of ways. As undergraduates, the Scholars were able to focus more on their studies because they did not have to work part-time jobs and they did not incur as much student loan debt as they would have without the scholarship funds. The financial perks received as undergraduates had secondary effects as in-service teachers; some Scholars were able to go to graduate school sooner, take a lower paying job, buy a house, and purchase supplies for their classroom. The financial perks associated with the scholarship helped to combat some of the typical issues associated with low teacher salaries and provided a more positive financial

situation for the Scholars. These effects should be celebrated and shared with other college students eligible for such a program as it may help with recruitment efforts.

Opportunities provided within the Noyce Program helped to raise the esteem of the Scholars and seemed to help them view teaching as a profession and as a career. Paying for the Scholars to attend conferences and network with highly motivated and effective teachers provided opportunities for the Scholars to be motivated by their peers. Exposing the Scholars to other highly effective STEM teachers provides inspiration and mentorship that can positively impact their career.

The classroom instruction of all participants, Noyce and non-Noyce Scholars, seemed to follow traditional models of instruction. Overall, there seemed to be little difference in the classroom contexts between the two groups and this implies the Noyce Program had little influence on the Scholars' classroom contexts. This signifies the challenges behind changing the teaching practices of STEM teachers. Implementing less traditional methods of teaching, especially for novice teachers, is challenging because it involves shifts in philosophies and school cultures. Additionally, many mathematics and science classes are standardized across departments and this may make it difficult for teachers to be innovative, creative, and execute less traditional styles of teaching.

## Importance of the Research

Throughout this dissertation, researchers unveiled some interesting discussion points for stakeholders invested in teacher recruitment, preparation, and retention. Programs interested in reflecting on and re-designing the programmatic structure can use some of the results and ideas presented in this dissertation as discussion points for programmatic improvement. The longitudinal research design used in the studies provides information that developed overtime

and not the single snapshot used in some studies. The overall picture of STEM teaching and the perceptions of STEM teachers are more complete when data is collected through the use of longitudinal studies and thus helps to highlight the important factors, endured over time, involved with STEM teacher recruitment, preparation, and retention.

## Study Limitations

The sample size of the studies in this dissertation is small. Additionally, the participants were all from the same teacher preparation program and some of the participants knew a few of the researchers because of the researchers ties with the university's Noyce Program and secondary STEM teacher preparation program. As such, the findings from these studies cannot be generalized to a larger population and should not be viewed as a representation of all Noyce Scholars. The findings researchers presented in this dissertation give information for other programs to consider and provide a platform for further discussion on STEM teaching.

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## APPENDIX A

Table 21. Descriptive Statistics and Results from Mann-Whitney U Test for the Question "Which of these were apart of your experience in your teacher certification program?"

| Question | Noyce | | Non-Noyce | | | |
|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Mean Diff | M-W U |
| Opportunities to interact with adults from different cultures | 1.45 | 0.506 | 1.38 | 0.492 | 0.07 | 0.564 |
| Opportunities to interact with children from different cultures | 1.34 | 0.484 | 1.12 | 0.336 | 0.22 | 0.043* |
| Education about different cultures | 1.28 | 0.455 | 1.16 | 0.369 | 0.12 | 0.259 |
| Class(es) in teaching methods specific to your subject area (e.g., science or math) | 1.03 | 0.186 | 1.09 | 0.296 | -0.06 | 0.354 |
| Education about how to work in high needs schools specifically | 1.52 | 0.509 | 1.66 | 0.483 | -0.14 | 0.274 |
| Opportunities to observe/work at high needs schools (not student teaching) | 1.21 | 0.412 | 1.25 | 0.44 | -0.04 | 0.692 |
| Student teaching experience | 1.1 | 0.31 | 1.06 | 0.246 | 0.04 | 0.564 |
| Student teaching experience in a high needs school | 1.52 | 0.509 | 1.66 | 0.483 | -0.14 | 0.274 |
| A guaranteed job (assuming successful completion of program) at a participating school district | 1.83 | 0.384 | 1.84 | 0.369 | -0.01 | 0.866 |
| Mentoring experiences provided by your certification program during your first year of teaching | 1.72 | 0.455 | 1.69 | 0.471 | 0.03 | 0.756 |
| Mentoring experiences provided by your district during your first year of teaching | 1.24 | 0.435 | 1.16 | 0.369 | 0.08 | 0.407 |
| Mentoring experiences provided by your certification program during your second year of teaching | 1.79 | 0.412 | 1.84 | 0.369 | -0.05 | 0.610 |
| Mentoring experiences provided by your district during your second year of teaching | 1.76 | 0.435 | 1.72 | 0.457 | 0.04 | 0.726 |
| Continuing contact with participants in your teacher education program | 1.72 | 0.455 | 1.53 | 0.507 | 0.19 | 0.124 |

## APPENDIX B

Table 22. Descriptive Statistics and Results of Mann-Whitney U test for question "To what extent do you agree or disagree with each of the following statements?"

| Statements | Noyce | | Non-Noyce | | Mean | |
|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Diff. | M-W U |
| The school administration's behavior toward the staff is supportive and encouraging. | 3.38 | 0.775 | 3.16 | 0.92 | 0.22 | 0.298 |
| I am satisfied with my salary. | 2.93 | 0.842 | 2.78 | 0.941 | 0.15 | 0.525 |
| The level of student misbehavior in this school (such as noise, horseplay or fighting in the galls, cafeteria, or student lounge) interferes with my teaching. | 2.10 | 1.145 | 1.78 | 0.906 | 0.32 | 0.348 |
| I receive a great deal of support from parents for the work I do. | 2.55 | 0.870 | 2.62 | 1.008 | 0.22 | 0.690 |
| Necessary materials such as textbooks, supplies, and co py machines are available as needed by the staff. | 3.31 | 0.806 | 3.28 | 0.813 | 0.03 | 0.823 |
| Routine duties and paperwork interfere with my job of teaching. | 2.72 | 0.96 | 2.44 | 1.014 | 0.28 | 0.324 |
| My principal enforces school rules for student conduct and backs me up when I need it. | 3.0 | 0.756 | 3.0 | 1.107 | 0 | 0.549 |
| Teachers in this school consistently enforce rules for student behavior, even for students who are not in their classes. | 2.45 | 0.827 | 2.47 | 0.983 | -0.02 | 0.860 |
| Most of my colleagues share my beliefs and values about what the central mission of the school should be. | 3.03 | 0.823 | 2.84 | 0.847 | 0.19 | 0.261 |
| The principal knows what kind of school he or she wants and has communicated it to the staff. | 3.17 | 0.759 | 3.03 | 1.062 | 0.14 | 0.894 |
| There is a great deal of cooperative efforts among staff members. | 3.21 | 0.62 | 3.13 | 0.942 | 0.08 | 0.911 |
| In this school, staff members are recognized for a job well done. | 3.24 | 0.786 | 2.94 | 0.840 | 0.30 | 0.118 |
| I worry about the security of my job because of the performance of my students or my school on state and/or local tests. | 1.38 | 0.561 | 1.47 | 0.879 | -0.09 | 0.933 |
| State or district content standards have had a positive influence on my satisfaction with teaching. | 1.93 | 1.033 | 2.16 | 1.051 | -0.23 | 0.441 |
| I am given the support I need to teach students with special needs. | 2.66 | 1.111 | 2.59 | 1.103 | 0.07 | 0.712 |
| The amount of student tardiness and class cutting in this school interferes with my teaching. | 2.17 | 1.037 | 2.03 | 1.092 | 0.14 | 0.804 |
| I am generally satisfied with being a teacher at this school. | 3.45 | 0.910 | 3.37 | 0.871 | 0.08 | 0.561 |
| I make a conscious effort to coordinate the content of my courses with that of other teachers. | 3.07 | 0.998 | 3.13 | 0.942 | -0.06 | 0.852 |

## APPENDIX C

The questions extracted from the semi-structured interview questions from fall 2015 to which only Scholars responded are:

1. What experiences during your teacher preparation program, if any, were extra because you were Noyce scholar?
2. Was there anything different for you as a Noyce scholar compared to other students in your preparation program?
3. Is there any particular role the Noyce money played in your decisions throughout the process? (Becoming a teacher? Leaving the program?)
4. How would things have turned out if you did not receive the Noyce money?

## APPENDIX D

The questions from summer 2015, 2016, & 2017 survey to which only Scholars responded are:

1. Did you first learn about the Noyce scholarship before or after you decided to become a teacher? (answer choices: before, after)
2. Did any of the following help you learn about the Noyce scholarship? (answer choices: website, advisor, career center, other – describe)
3. Would you have become a teacher if you had not received the Noyce scholarship? (answer choices: yes, possibly, no)
4. Would you have decided to teach in high-need school if you had not participated in the Noyce scholarship program? (answer choices: yes, possibly, no, I have not taught in high-need school)
5. How influential was the Noyce scholarship money in your commitment to: (a) become a teacher? (b) complete the teacher certification program? (c) take a teaching job? (d) teach in a high-need school? (e) remain in teaching in a high-need school for the full term of your commitment? (f) remain in teaching in a high-need school beyond the full term of your commitment? (ratings: very influential, somewhat influential, not very influential, not at all influential)
6. What requirements were you expected to meet to fulfill your obligation to the Noyce Program after you finish your schooling? (open ended question)
7. Did you have any opportunity or responsibilities during your certification program because you were a Noyce Scholar (e.g., special seminars available or required)? (open ended question)
8. Did the scholarship allow you to do anything you wouldn't have been able to do otherwise outside of your schooling (e.g., not have to take a part-time job, teach in a area with a higher cost of living travel to conferences, etc.)? (open ended question)
9. Do you have any suggestions for improving your experience in the Noyce Program and/or better preparing you to teach successfully in high-need settings? (open ended question)