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Impact of teacher scientist partnerships on high school students' perceptions of science

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IMPACT OF TEACHER SCIENTIST PARTNERSHIPS ON HIGH SCHOOL STUDENTS' PERCEPTIONS OF SCIENCE

An Abstract of a Thesis

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Master of Arts in Science Education

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ABSTRACT

There exist a multitude of global issues in the 21^{st} century that can be addressed with the scientific process. In response to these dilemmas, there are a number of education initiatives that aim to raise interest in science careers. This study provides an evaluation for one such effort. Over 200 students from 4 different high schools and 4 teachers were presented with a pre to post survey to measure the impact of Research Experience for Teachers (RET) curricula. High school science teachers participated in a research experience, created curriculum with a scientist, taught the content in their classrooms, and distributed the survey instruments before and after the teachings. The surveys included questions addressing perceptions of scientists and science careers. The findings showed statistically significant differences pre to post for quantitative student survey responses. Qualitative student responses were categorized and compared pre to post for three different questions. Students had a statistically significant change in understanding of where scientists perform their work. Further pre to post student survey analysis indicated science perception differences between male and female respondents, prompting a need for further research. This report includes no significant findings for the teacher responses, potentially due to a low sample size. Suggestions for curriculum design and RET program structure are discussed, as well as the need for future studies to include a larger sample size and a slightly modified survey instrument to account for habituation bias.

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has been approved as meeting the thesis requirement for the

Degree of MASTER OF ARTS IN SCIENCE EDUCATION

Date	Dr. Lyn Countryman, Chair, Thesis Committee
Date	Dr. Jody Stone, Thesis Committee Member
Date	Dr. Dawn Del Carlo, Thesis Committee Member
Date	Dr. Patrick Pease, Dean, Graduate College

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Writing this thesis has been a joy, but it has been quite the task! The amount of effort required for this type of project makes it something to be proud of. The cliché stands, that anything worthwhile in life takes work! I am grateful for those who helped me along the way, and couldn't have completed this project without the encouragement and guidance of my advisor, Lyn Countryman, and members of my thesis committee, Jody Stone and Dawn Del Carlo. All three have been illustrious science education faculty, and inspired me to dig deeper into science education research. This work would also not be possible without the contributions of Adah Lesham, and the support of the RET lead teachers, Craig Walter, Eric Hall, and Maureen Griffin. They allowed me time to present my project to fellow teachers and encouraged participation from my colleagues. I'd also like to give thanks to my coworkers Ryan Lensing and Peg Conlon, who both suggested to me that I apply to UNI, and were insatiably pushing me to pursue the thesis option. Additionally, I received encouragement and financial support from the administration at Dowling Catholic High School. Finally, I'd like to give special thanks to my wife and best friend, Alexis. She listened to me go on and on about my work, readings, and ideas. I didn't stop learning (and talking) and I'm *pretty sure* she never stopped listening. It is with these contributions, and many more that this research has been made possible.

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CHAPTER 1

INTRODUCTION

A common goal for educational stakeholders is to contribute to and observe the development of students. At the turn of the century and well over a decade into it, problems with the U.S. school system and recommendations for its improvement are well established but highly polarized. Many pundits argue testing is overused to the point of crippling schools, urging that real learning does not happen with standardized testing. Others state there needs to be strict commonality among the nation's schools, and that standards and tests serve as a benchmark, and must be used accordingly (Marzano, Yanoski, Heogh, & Simms, 2013). No matter the disagreement, incumbents of the competing paradigms can agree there exists a need to integrate science and technology in the classroom, and the work in which students participate should include critical thinking, rigor, and relevancy (Wagner, 2008). Rothstein and Santana (2011) suggest that students investigate their own questions. Students succeed in a classroom that encourages critical thinking, research design, inquiry, and an abounding respect for each student’s mind (Rothstein & Santana, 2011).

Efforts to increase the amount of critical thinking and meaningful inquiry learning in the classroom have taken form in schools and universities across the nation. Research Experiences for Teachers (RET) is such a movement. The objective is to provide high school teachers professional partnerships with scientists and research experiences that extend to the classroom. RETs are often summertime programs where teachers are immersed in a full time position working in industry or at a research lab for 4-8 weeks.

After teachers complete the program, many institutions require a classroom integration component, where teachers are extending the research learning into the classroom by creating and integrating curriculum that models the research process (Dempsey, Hibbet, & Binder, 2007).

Many RET programs have been evaluated to determine success in providing high school teachers with a meaningful partnership. Throughout their implementation, RET programs increased student academic performance across a number of standards, and had a positive wide reaching impact on teachers' perception of science and inquiry learning among students (Miranda & Damico, 2013; Science teacher's research, 2009). The most successful teacher-scientist partnership models are ones in which the interaction between the RET participant and the scientist extends to the teacher's classroom, where the scientist is also in contact with the students. A curriculum is agreed upon prior to implementation, and then the scientist aids in and leads some of the instruction. Ultimately, the partnership is thought to be most effective if the designed curriculum involves an inquiry component for the students, with guidance and leadership coming from both the teacher and the scientist (Dempsey et al., 2007).

The RET partnership and curriculum integration is a positive experience for the teacher and respective scientist (Grove, Dixon, & Pop, 2009). There is research indicating this is the case, but there is a gap in the research when considering the *impressions students* have following their classroom experience with the teacher and scientist. Many RET programs disseminate evaluations, surveys, and oral reviews to their participants and glean useful information about teacher perception of the program and its utility for their classrooms. These types of studies will be reviewed in this document to gain an understanding of the RET programs' impact on the intended classrooms. The apparent problems which need be addressed are not whether the RET programs improve achievement in the classroom, for that much has been established. For this study one focus will be the perceptions of the students whose teacher was an RET participant and who implemented inquiry curriculum in the classroom following the RET. The main areas for concern in this study are students' views of science and scientists, science as a potential career, student willingness to participate in summer research institutes.

CHAPTER 2

LITERATURE REVIEW

Research Experience for Teachers (RET) Model

The nature of science leads to numerous breakthroughs throughout the years, making for an exciting, dynamic, and challenging curriculum for those involved in the teaching of its content. Research Experience for Teachers (RET) is a program that exposes science teachers to the new developments in science because oftentimes the teacher participants are assisting in cutting edge research, and even design unique projects of their own. Though RET can be funded from a number of different sources, RET assignments are commonly part of National Science Foundation (NSF) funding given to research laboratories conducting NSF approved science work. Under the direction of a principal investigator (P.I.), a high school teacher works with research mentors to perform lab tasks and design a research project (Faber, Hardin, Klein-Gardner, & Benson, 2014). The goal of the program is to provide teachers with first-hand research experiences, so teachers will then be better equipped to design lessons reflecting the nature scientific inquiry. Specific teacher professional development and associated outcomes can vary from program to program. Some RET programs focusing on developing a teacher-scientist partnership become an ongoing collegial relationship, while other programs focus on teacher curriculum development without bringing the teacher's students in contact with the scientist (Miranda & Damico, 2013; Science teacher's research, 2009). This research project will focus on the impact of one particular university's RET program.

Iowa State University (ISU) hosts an RET program each summer, where thirty teachers from across the United States are selected to participate in the seven week research experience. Iowa State lists on its website the specific objective of its program is to, “Provide teachers with research experiences and on-going relationships with career scientists that will enable them to share the latest developments in STEM fields with students and inspire their students to learn more about science and engineering and their related career paths,” (Lesham, 2016, p.1). During the RET, teachers engage in research under the guidance of an ISU faculty member, develop relationships with ISU researchers, spend structured time with fellow teachers to reflect about the experience, and design curricula for their classroom with the expectation that the ISU faculty member will interact with the high school students of their teacher mentee (Lesham, 2016).

Teacher research projects span an array of topics from mathematics engineering and technology to chemistry and biology. Teachers who enter the program are encouraged to apply for mentorship in an area that fits their classroom needs. Participants are offered a stipend, travel allowance, on campus housing, a small grant for purchasing classroom supplies, and optional graduate credit for their time spent at the institute. The primary researcher for this project has been an RET participant at ISU in the past, and conducted this project with the teachers who participated in the ISU RET during the summer of 2016.

Outcomes of RET

One RET program experience involved Dempsey and coworkers. In their research they described the RET program, Dempsey’s experience with RET, and provided recommendations to teachers who would be interested in such a program (Dempsey et al., 2007). The researchers involved fungal ecology and evolution in the project, and as a result of their work, the teacher and a mentor designed and implemented curriculum to be used in the teacher's classroom.

Dempsey indicated he and his partner scientist elicited a positive response from the high school students, who studied fungal biology, molecular ecology, and evolution. The teacher stated there were some shortcomings to the integration, however, indicating that the module could have been designed in a way that would better engage students (e.g. be more student-centered). He resolved to redesign the curriculum with the help of his collaborating scientists, and to continue the ongoing communication necessary to implement a meaningful unit for his students. This particular reflection illustrates the positive impact the program had on all stakeholders, but also showed the need for ongoing collaboration to improve the curriculum after its inaugural implementation. Although resolutions to improve the curriculum were made, the researchers did not collect any data on student perceptions of science following the curriculum. After analyzing a single experience, other articles with larger amounts of teacher feedback are considered.

One such study examined the long-term impacts of an RET-like professional development program called *Teachers in the Woods* (Dresner & Worley, 2006). *Teachers in the Woods* provided teachers with the opportunity to work alongside scientists in a field research setting during the summer program. The intended outcome was that teachers would gain an appreciation and understanding of the scientific process, and therefore feel confident in extending a rigorous critical thinking process to the students in their classrooms. For this study, administrators of the program interviewed teacher participants, asking questions about benefits of participation, teacher outcomes, and student outcomes. A result of the program was teacher-teacher and teacher-scientist collegiality in and outside of the duration of the experience. Teachers indicated collegiality improved during the program, stating that networking between scientists and teachers continued even after the conclusion of the summer. There were also many positive remarks associated with content knowledge appreciation, and redesign of curriculum to better mirror the process of science rather than just memorizing the facts of science. This type of study provides a framework for a survey process that could be conducted on student participants who completed the curriculum designed and taught by teacher-scientist teams.

Another research study, conducted on an NSF grant funded RET program, provides meaningful information about teacher outcomes and teacher perception on how the RET has influenced their classroom (Pop, Dixon, & Grove, 2010). Thirteen teachers participated in an RET and then were evaluated using a number of qualitative data collection tools such as pre- and post-program interviews, analysis of redesigned curriculum and lesson plans, and classroom observations. The researchers aimed to indicate how the teachers internalized and used the experience to better their teaching practice. Outcomes included improved teacher perception of inquiry-based curriculum, experimental design, the nature of science, process skills and communication. These data illustrate the efficacy of RET in terms of improving teacher perception. It remains to be seen if this type of research experience would translate to improving student perceptions of science.

Student Perceptions of Science Following Inquiry Curriculum

Students typically hold stereotypical images of scientists especially if they have never been in contact with scientists (Chambers, 1983). However, specific curriculum can help to reverse some false notions students have about scientists. Fortunately the research is rich in this regard, with studies ranging from elementary to college age students' perceptions documented following their participation in hands-on science. There are also studies that have been conducted to ascertain information about students' perceptions of science and scientists following interaction with scientists in the classroom. One project was conducted when a scientist came into 7th and 10th grade classrooms for a weeklong educational experience focused on nanotechnology. Students were interviewed, surveyed, and completed the Draw a Science Test (DAST) prior to and after the experience (Painter, Jones, & Tretter, 2006). The DAST is typically administered as a pre to post assessment, where students are asked to draw a scientist and then submit that drawing to the teacher. The DAST is then analyzed using a rubric to determine if students are drawing stereotypical images of scientists, or if there is a general inclusivity within the tested group (Chambers, 1983).

Results indicated that fewer than 10% of the student participants had interacted with scientists prior to the experience. These data are reported despite the participating school being located in a region that employs many scientists. The first items discussed in the results are the prevalence and meaning of school and scientist partnerships. In the

United States, there has been a push to increase the opportunities for students to interact with scientists, but too often the goal becomes unrealized. The authors proclaim a newfound resolve to collaborate with area teachers to help them network with scientists that could enter classrooms in their schools. Furthermore, the researchers stated student perceptions of scientists were altered as a result of interacting with the scientist during the unit. The students' preconceived notion of a scientist, oftentimes a middle aged, white man wearing a lab coat and holding glassware, changed dramatically for many students as a result of their interaction with the scientist.

This study is an interesting example of how students' perceptions can be distorted despite living in a scientist rich area. Even a short duration of time with a scientist led to significant change in perception of scientists and relevancy for each student's life. Many of the student participants stated they could see themselves being a scientist after such an experience, this being in stark contrast with the responses collected prior to the experience.

Similar results were found with elementary age students who were in contact with veterinary and health scientists during an animal and health science unit (Soo Yeon et al., 2015). The researchers set out to determine to what extent a unit with student-scientist interaction, portrayal of science concepts through images, and hands-on learning would influence student perceptions of science and scientists. A Likert-scale survey was administered before and after the unit and students were also assessed with the DAST. Soo Yeon et al. (2015) showed the curriculum caused a positive increase in student attitude toward science, increased students' desire to become a scientist, and decreased student stereotyping of scientists. Many students found it difficult to name a type of scientist or a scientist they knew prior to the unit. Following the curriculum implementation, students listed multiple types of scientists and referred to the doctor, veterinarian, and teacher as scientists they knew. These results are encouraging for teachers who wish to improve student perception of scientists and science, and are willing to network with scientists and implement a similar type curriculum. Increase in positive impression of scientists was also identified in a study examining preservice teachers who had participated in science research vs. those who had not participated as a researcher in any project (Lederman & Lederman, 2014). It seems experience working with scientists in the classroom or on a project usually results in an overall positive perception toward science and science careers.

The ISU RET program and resultant classroom curriculum are designed to be a similar type experience to the aforementioned, but there are key differences. One difference is that the ISU RET program classroom-scientist collaboration is meant to be ongoing, where students are in contact with the scientist more than just one discrete period in a year. In conclusion, the literature cited brings to light the efficacy of the RET program, and also the positive impact that bringing a scientist into the classroom has on students' perceptions of scientists. Still, the ability of the *RET* teacher-partnership curriculum to influence *student* perception needs to be examined.

Theoretical Framework

The Social Cognitive Career Theory (SCCT) is useful when considering the implications of a student-scientist interaction in an inquiry-based curriculum. By using the SCCT as a framework, it becomes easier to understand how student attitudes about science, perception of how science is relevance to their lives, and desire to work in a scientist's career can develop. According to SCCT, a person's interest in a career changes over time as people wrestle with information received from personal and environmental inputs. The SCCT can be broken into essential components, each part necessary for the teacher to address in order to maximize student perceptions of science careers (Figure 1).

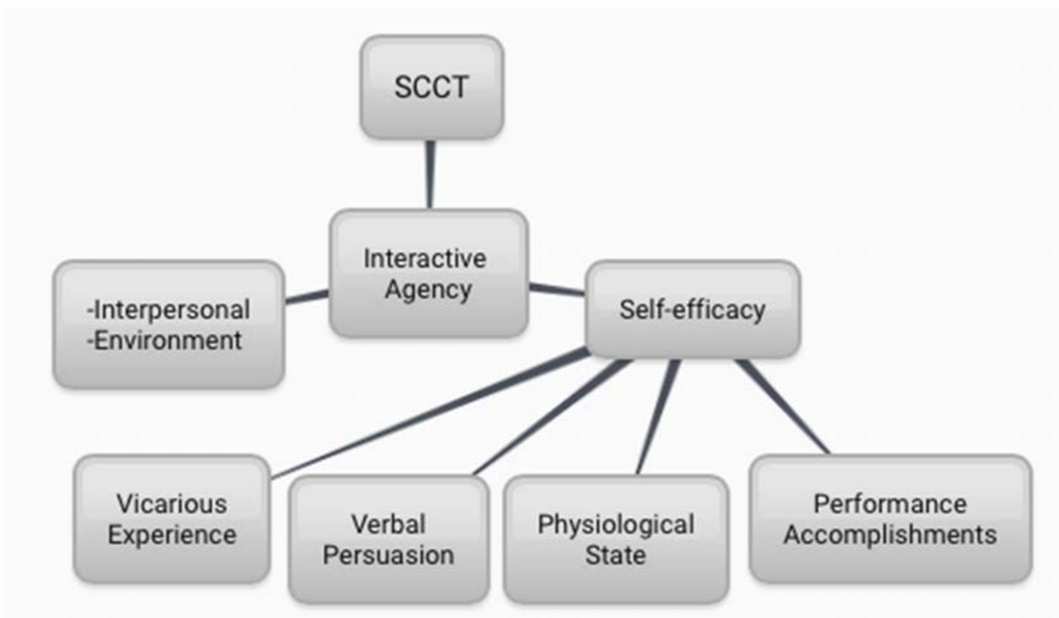

Figure 1: Concept Map of Social Cognitive Career Theory.

The SCCT states individuals will develop perceptions about their abilities in light of their experiences. Self-evaluation in a classroom setting can have a negative or positive impact on self-efficacy and interactive agency, and ultimately influence career choices and perception of particular careers and associated professionals (Lent, Brown, & Hackett, 1994). Interactive agency refers to the combination of self and surroundings as participating agents in the cognitive development of an individual. Two separate agents, one being self-efficacy and the other a combination of interpersonal relations and learning from the direct environment (classroom, lab, field, etc.), work within a reciprocal system (Bandura, 1989). Since interpersonal/environmental learning and self-efficacy influence student perception of careers, it is important to study these components to understand student development within the framework of SCCT.

Bandura says the sources for self-efficacy are performance accomplishment, vicarious experience, verbal persuasion, and physiological state (Bandura, 1977). Performance accomplishments are personal mastery experiences, which are acquired through successful completion of an assignment. The information collected by the individual can have either positive or negative valence, that is to say, emotional attachment. Positive and negative valence is said to be the most influential piece of information that contributes to a person’s self-efficacy (Bandura, 1989). Furthermore, Bandura (1977) posits mastery of a difficult task produces a greater level of self-efficacy than mastery of a task requiring little effort. Self-efficacy is also determined by vicarious experience, which is essentially the observation of others who either successfully or unsuccessfully perform a task. Vicarious experience has the greatest contribution to self-efficacy when an individual or group of individuals with whom the observer identifies successfully completes a performance task.

The final two sources of efficacy identified by Bandura (1977) include verbal persuasion and physiological state. These two sources are closely linked to the environment where tasks or observation of others occur. Verbal persuasion information reaches students when a teacher gives praise, or fellow classmates make positive comments about a student's performance. Physiological state is influenced by the health of the individual, particularly the mental health of the individual. For a positive contribution to self-efficacy, a student should feel emotionally comfortable in the setting where observation or task performance is taking place. Therefore, positive and safe learning environments are absolutely essential to development of self-efficacy and an overall development of agency in the student. These four sources of contributing information for self-efficacy can be taken into consideration when teachers design the RET curriculum with their research mentors. To maximize learning and improved science perceptions, according to the SCCT, teachers must make an effort to ensure that the student paints all facets of self-efficacy and interpersonal relations with a positive valence.

In the following section, the RET Teacher-Scientist Partnership (TSP) framework for Iowa State University's RET is elaborated upon, with special consideration given to the four contributing categories of information related to self-efficacy: performance accomplishment (students successfully complete challenging assignments), vicarious experience, verbal persuasion (positive comments on a student's performance), and physiological state (students feel comfortable in the class environment.

Teacher Scientist Partnership (TSP)

Iowa State's RET TSP is designed in a way that should translate to student development according to the SCCT, with positive response to science careers. The TSP is a framework for evaluating the partnership and curriculum developed by the teacher RET participant and their research mentor (Griffin & Hall, personal communication, March 16, 2016). The TSP framework, shown in Figure 1, shows a triadic relationship between teacher-partner interactions, program structure, and student engagement. When teachers enter the RET program it is expected the teacher and scientist will develop a partnership and curriculum that will impact the classroom. The TSP framework is useful for evaluating the type of partnership established by the teacher and the scientist. The general goal is to move to greater collaboration and authentic work for students, which are outlined within the framework. In the ensuing section, the three components of the TSP framework are explained, and then the classroom implications are related to self-efficacy and the SCCT

Teacher-Partner Interactions

Interactions range from "my work, my time" to "holding a shared responsibility for student achievement," (Figure 2). This is not to say that the professor needs to spend enormous amounts of time, but that the teacher and partner are cognizant of establishing at least a parsimonious relationship effective for the scientist, teacher, and students. There are many positive implications for self-efficacy if teacher partnerships are able to share responsibility for student achievement.

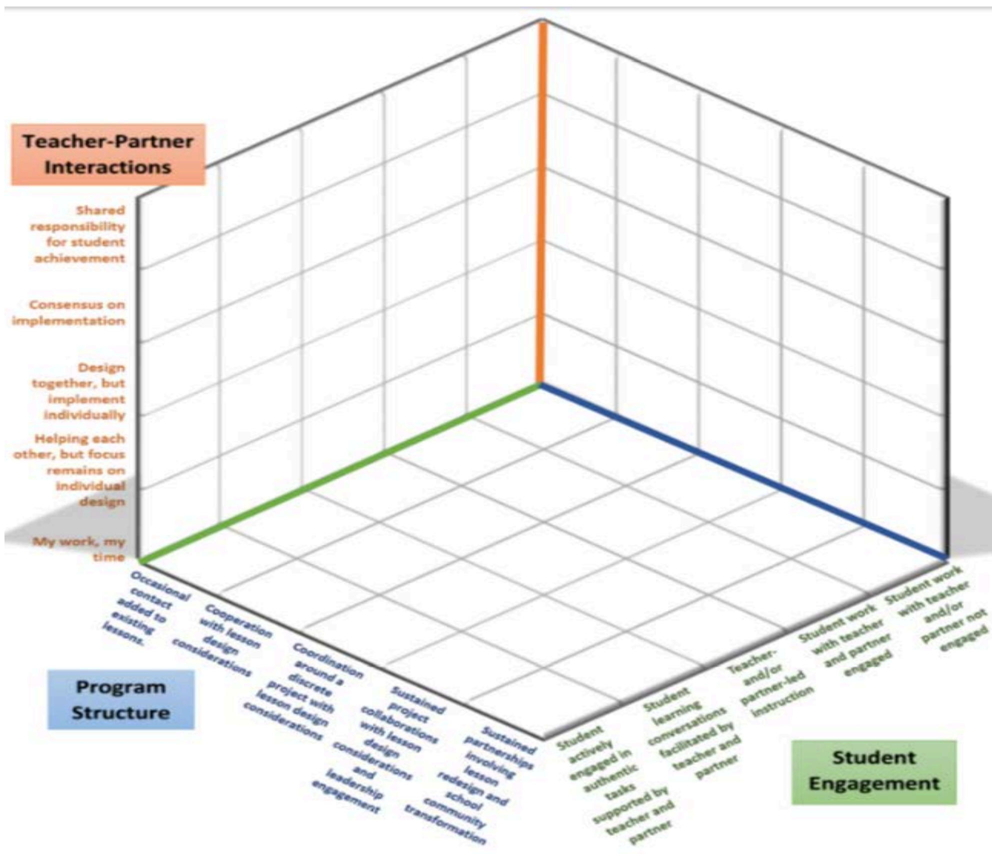

Figure 2: The Teacher Scientist Partnership (TSP) Framework. Teacher-partner interactions, program structure, and student engagement form a triadic interrelationship for teacher partnerships. The matrix provides three points, one for each facet of the triad. The points are plotted on the matrix and make a triangle. A large triangle indicates a better TSP.

Bandura (1989) described the interactive agency model, where students need positive input from various sources to continue to increase their self-efficacy. Having positive input and persuasion from an active scientist qualifies as verbal persuasion that can lead to positive valence toward science related tasks. According to the SCCT, students with increased self-efficacy and agency toward science will perceive scientists in a more positive light and would be more likely to seriously consider science as a career.

Student Engagement

Another piece of the TSP framework that teachers and scientists consider as the partnership is established is student engagement. It is argued if both members of the teacher-scientist partnership place emphasis on student achievement, more fun and challenging tasks will be developed. Scientists are capable of helping teachers create more rigorous and authentic tasks for students to perform. Bandura (1977) suggests that more rigorous tasks help students make greater leaps in self-efficacy following the mastery of those assignments. The student engagement piece involved in the TSP ranges from “student work with teacher/partner not engaged” to “student actively engaged in authentic tasks supported by teacher and partner.” As teachers are developing curriculum with their scientist mentor, the two pay special attention to the engagement component as they try to develop challenging and meaningful curriculum for the students. According to the SCCT, after implementing engaging and authentic work in the classroom, the students’ increase in self-efficacy should translate to a greater interest in science and science careers.

Program Structure

Ranging from “occasional contact added to existing lessons” to “sustained partnerships involving lesson redesign and school transformation,” program structure is the third component of the TSP framework. The occasional contact component refers to either a phone call or a few email exchanges after the RET. A goal for the partnership is to move the coordinate along to a more sustained partnership. It is a difficult task to completely transform a school, but a sustained partnership involving consistent scientist contact with teacher and students is a feasible goal within a summer. Students will have better success in developing a relationship with the scientist if they identify with their teacher. The more frequent and meaningful the contact, especially when students are involved, the more comfortable the students become with the scientist. When the scientist does visit the classroom to demonstrate various activities, students may be more inclined to vicarious learning due to the established partnership. Supportive and consistent structure appeals to the physiological component of self-efficacy. Frequent and meaningful contact with the scientist stands to improve students' interest in science and science careers.

The proposed study will assess how the ISU RET teachers' implementation of TSP curricula affects student perception of science and scientists, and the students' desire to pursue science as a career. Iowa State University RET has recently shifted (2016) to the TSP as a guiding framework for successful translation of teacher development to classroom impact. Therefore, there exists a need to evaluate the efficacy of the TSP framework, to help make further decisions about continuing to implement the TSP as is, or making modifications that would enable greater success for classrooms.

CHAPTER 3

METHODS

Research Questions

This project explores if there is a change in the perception of science, scientists, and science careers for students whose teachers participated in RET. The research questions for this project are: Does an RET teacher-scientist partnership influence students' (a) feelings about science, (b) perception of the relevance of science in their lives, (c) perception of scientists, and (d) desire to work in a science related career?

Study Design

This study used a multi-group, pre to post design to assess the effect of student participation in RET curricula on student science perceptions. These curricula were designed and implemented by high school teachers in partnership with scientists. Teachers who implemented RET curricula in their classrooms provided pre to post surveys, using the website SurveyMonkey (2017). The surveys were provided to the teachers by the primary researcher during the RET summer session and at the start of the fall 2016 semester. Teachers also participated in a survey, where they rated their partnership on the TSP framework. Both teachers and students were assigned codes to ensure anonymity and so student and teacher data could be linked. The TSP teacher feedback and student survey results were analyzed to determine (a) If students changed their perceptions of science and their likelihood to pursue a science career and, (b) If any relationship existed between TSP evaluation feedback and student survey results.

Participants

Participants in this study were high school students ranging from grades 9-12 from the state of Iowa. There were 149 total high school students who took the pre-survey. Of those students, 66 completed the post-survey. A grade level breakdown is included in the results section for further analysis. Thirty-seven percent of student participants identified as male, 58% identified as female, and 5% preferred not to indicate a gender. Teacher participants were high school science teachers in the state of Iowa. These teachers self-selected to participate in RET and were paid to do so. There were four teacher participants, each identifying as a white male.

IRB Approval

IRB approval was sought and obtained prior to dissemination of any surveys to protect all affiliated parties. An electronic consent/assent form with a parent letter ensured privacy and safety for those involved in the survey. In this particular project, surveys were anonymous for students and teachers. A physical letter of consent was considered to be very impractical for this study because there were many students participating, making the collection of the papers time consuming, expensive, and difficult for all affiliated with the project. Collection of parental consent forms would have been an issue because collection would have had to be done by all of the RET teacher participants. This collection method could have caused undue influence on the participants and may have interfered with the results. It is for that reason that a waiver of consent was requested and approved for IRB. The survey questions were low risk questions containing no identifiers and only asked questions about perceptions. A letter sent to the parents of the participants informed all members of the study, the risks, option to not participate, and the PI's contact information. Parents could have contacted the PI prior to taking the survey if parents would have liked additional information. Parents who chose not to consent simply declined to participate in the online survey. There was also assent information provided on the online survey for the students.

Materials

Two types of data collection methods were used in this study. A pre to post survey (Appendix A) was given to students and included questions about teacher identifier number, demographic variables, and Likert-scale items designed to address questions about student attitudes toward science, perception of science relevancy, interest in science careers, and likeliness to seek out and participate in high school science camps or summer research internships. Questions and student survey design had been adopted from an existing survey developed and distributed to student participants in a six-week hands-on science unit where students were in contact with scientists in the classroom (Soo Yeon et al., 2015). The instrument has already been validated before Soo Yeon's study, in a 2002 study assessing students' perceptions after an experience at a space center (Jarvis & Pell, 2002).

The first part of the student survey given in this study was a series of Likert-style questions where students ranked items from strongly disagree (1) to strongly agree (5). The data were explored using 2-proportion Z-interval statistics. The test was appropriate because the sample size was normally distributed and sufficiently large according to the central limit theorem (Bock, Vellemen, & De Veaux, 2010). Sample sizes of $N > 30$ are sufficient to assume normal distribution, and are generally uncontroversial (Mordkoff, 2016). Sample sizes in this study vary from 60 all the way to 2058, depending on how the data was categorized in the specific analysis. Further analyses of mean response data were compared using a 2 Sample Z interval test at a 95% confidence interval. A second component of the student surveys were three questions, modeled after some of the main issues addressed when researchers use the DAST. The questions were free response, so students' answers could have a wide degree of variability, and patterns unseen in the Likert-style survey may be observed. The questions were (a) Describe what a scientist looks like, (b) Describe where a scientist performs their work, and (c) Describe what a scientist does. These were intentionally made to be open-ended questions to allow students to include personal descriptions. Student responses were coded by the researcher and categorized to determine response trends.

Another survey (Appendix B) was distributed to the teachers, and also included a teacher identifier code, necessary to link the student survey results to the teacher feedback. Teachers answered questions about their perception of the curriculum implementation, and evaluated their TSP using the framework provided in Figure 1. Due to the small sample size of teachers, results are presented and discussed, but detailed statistics were not appropriate for analysis.

Procedure

Surveys and parent letters were disseminated to teacher RET participants at the conclusion of the ISU RET in the summer of 2016. The PI prepared packets containing randomly assigned teacher numbers and those packets were handed out by an unaffiliated person during an RET professional development session. Contact between the RET teachers and the PI continued (reminders and question answering), but at no point were teacher numbers shared with the PI. Teachers were instructed to have students take the survey prior to and after implementation of the curriculum designed during RET. Teachers took the survey after they implemented the curriculum. The survey window opened in September, 2016 and closed in May, 2017.

CHAPTER 4

RESULTS

Pre to Post Trends for Students

An unpaired t-test was performed to determine average differences from pre-test to post-test across all Likert-style survey items. Though a paired t-test is usually most appropriate for pre to post style studies, the difference in sample size for the pre and post groups in this study was cause for concern. An additional problem was that students didn't have an identifying code, so there was no way to determine which students took both pre and post-surveys. Although not optimal, there was no pairing information so an unpaired t-test was performed. T-test calculations were performed with the variances calculated for both the pre-survey and post-survey groups, and different sample sizes factored into calculation. Scores ranged from strongly disagree (1), disagree (2), unsure (3), agree (4), to strongly agree (5). All questions were worded in such a way that a higher ranking would indicate positivity toward science, scientists, or science careers. Combining these survey items assumes variability, as the fourteen survey questions were different. Furthermore, there were more responses collected for the pretest as compared to the posttest, indicating those samples provided some additional variability. The purpose was to determine if there was an overall effect across all items as a result of experiencing the RET curriculum. Differences in the average for the total scores were significantly higher ($t\ (2980) = 8.203$, $p < .0001$, Hedges' $g = 0.325$) for the posttest as compared to the pretest reported in Figure 3.

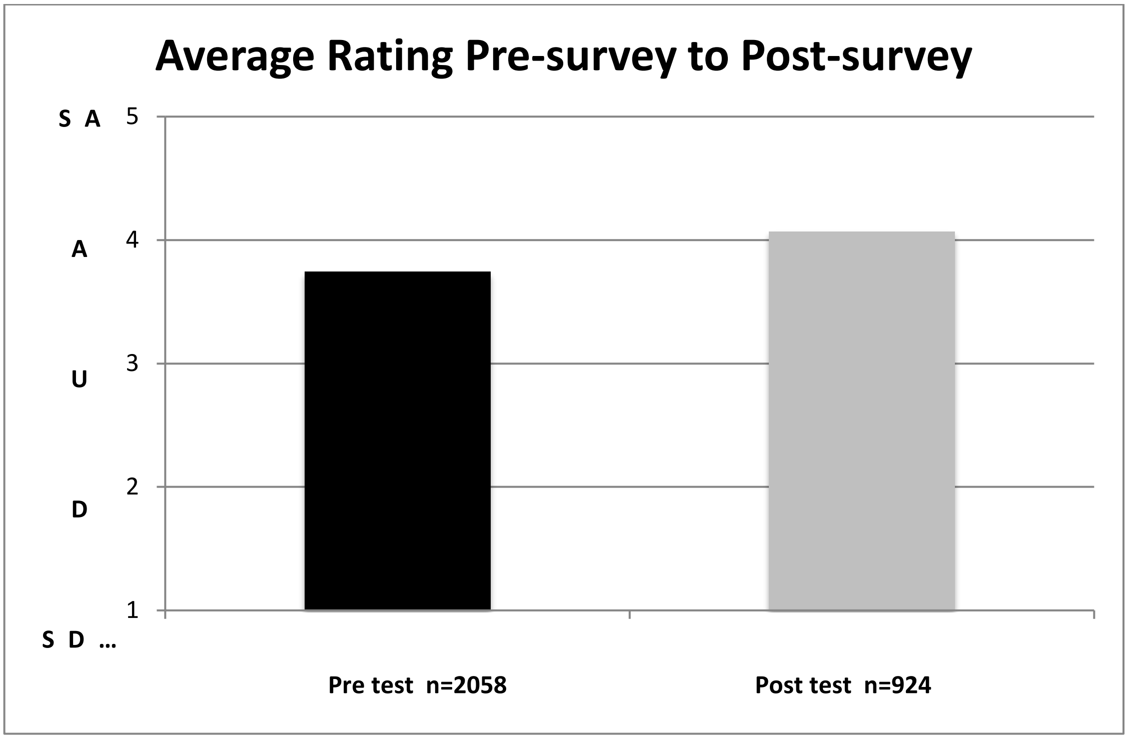

Figure 3. Mean scores for all fourteen responses on pre-survey and post-survey.

This rejects the null hypothesis, indicating there is an observed difference from pretest to posttest in this study. This data supports the alternative hypothesis the RET curriculum can impact high school students' perception of science and scientists.

For further analysis, survey items were partitioned into four categories (societal, personal, relational, and career), with each category consisting of closely related questions. Questions 1-5 on the student survey were categorized as societal, as in the student ranked their beliefs about how science relates to society. Questions 6-9 were categorized under personal as students rated their feelings about engaging in science activities. Items 10 and 11 were deemed relational because students responded with their perceptions about their personal relations with scientists, such as whether they have met a scientist. Finally, questions 12-14 were categorized as career because students indicated if they have an interest in pursuing science as a career. An unpaired t-test was used to compare the pre and post responses for each of the thematic categories. Again, there was some variability within each group, and also between the pretest and posttest groups. A null hypothesis assumed no mean difference between pre and post results for each of the survey categories. An alternative hypothesis was supported, as significant differences ($t(1068)=4.084$, $p<.0001$; $t(853)=2.979$, $p=.0009$; $t(408)=2.981$, $p=.0030$; $t(639)=6.261$, $p<.0001$) were observed between pre and post groups for each thematic category (Figure 4).

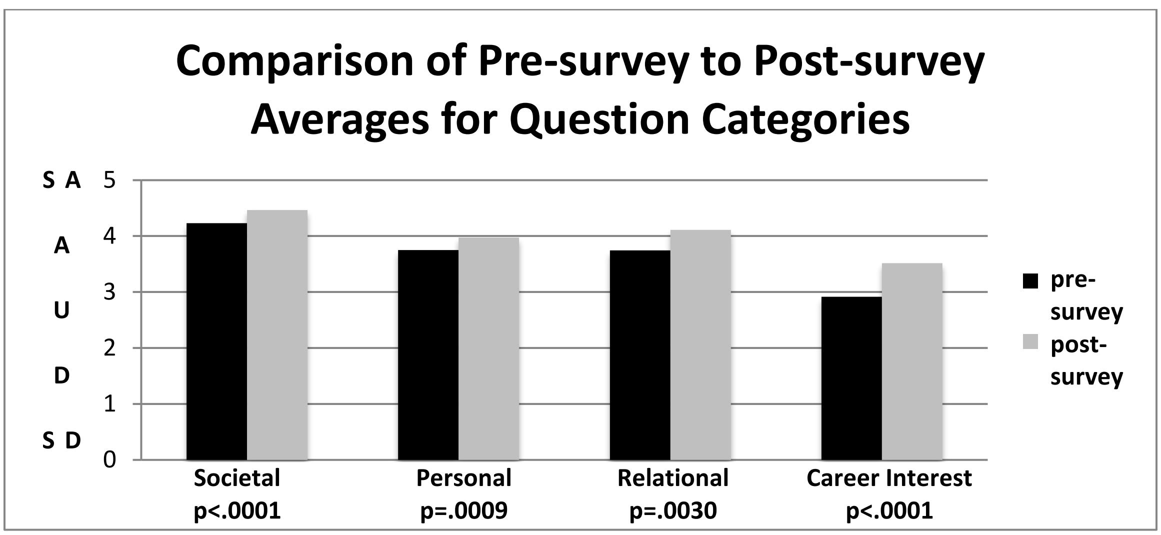

Figure 4. Mean scores were compared for each thematic category present on the student survey.

Table 1

Statistical analysis of thematic categories.

Category	Avg. Score	Difference	Avg. SD	Sample size	t-test result	Hedges' g effect size
Societal Pre	4.234	0.230	0.824	740	p< .0001	0.266
Societal Post	4.464		0.908	330	T= 4.084	
Personal Pre	3.750	0.223	1.010	591	p= .0009	0.221
Personal Post	3.973		1.014	264	T= 2.979	
Relational Pre	3.745	0.365	1.118	298	p= .0030	0.330
Relational Post	4.110		1.068	112	T= 2.981	
Career Pre	2.913	0.603	1.143	443	p< .0001	0.535
Career Post	3.517		1.095	198	T= 6.261	

A rejection of the null hypothesis for categorical responses led to further analysis of the survey items. While the sample sizes may seem large (Table 1), note that multiple related questions have been combined into a single category, yielding much higher samples. Essentially each student is represented between 2 and 5 times in each of the above categories.

An additional analysis was conducted on shifts in the percentage of respondents for each number within each question (Tables 2-5). For instance, if on the pretest a large portion of the sample rated an item a 3, and on the posttest there was a much smaller proportion of the sample ranking that item a 3, it is considered a shift. Each domain is studied using a 2-proportion Z interval test, first being the societal domain category (Graphpad Software, 2017; SurveyMonkey, 2017). This test was deemed appropriate to determine if a significant proportion of responses changed within the Likert-style rankings (Stangrom, 2017). Various shifts such as the example described were observed within the thematic category “Societal” perceptions (Table 2).

Results from Table 2 cannot be significant apart from certain assumptions about the data set. The sample size in the study falls within the generally accepted parameters stipulated in the Central Limit Theorem (N>30), and therefore assumes a normal distribution (Bock et al., 2010). The 2-proportion Z-test helps make sense of how shifts in the data are occurring. It seems plausible that positive opinions about science and society became more positive, because in all statistically significant cases there are shifts toward strongly agree. A similar analysis took place for the remaining thematic categories.

Table 2

Student proportions for societal category questions; A proportional breakdown of respondents for each survey item is listed, with statistically significant shifts (95% confidence interval) from pretest to posttest highlighted in light gray.

	1-SD	2-D	3-U	4-A	5-SA	Total	Average
Scientists use tools and technology to help people and animals.							
Pre %	0.68	1.35	7.43	42.57	47.97	N=148	4.36
Post %	1.52	1.52	3.03	31.82	62.12	N=66	4.52
Science helps keep people healthy.							
Pre %	0.68	1.36	10.88	42.86**	44.22**	N=147	4.29
Post %	3.03	1.52	7.58	25.76**	62.12**	N=66	4.42
I would consider a mathematician, doctor, or engineer to be a type of scientist.							
Pre %	2.04	6.12	25.17**	37.41	29.25**	N=147	3.86
Post %	1.52	1.52	10.61**	40.91	45.45**	N=66	4.27
Science affects everyone, including me.							
Pre %	1.35	1.36	6.76**	42.57**	46.62**	N=147	4.30
Post %	3.03	1.52	0.00**	24.24**	71.21**	N=66	4.59
Science can help make our lives better.							
Pre %	1.36	1.36	8.84	36.73	51.70	N=147	4.36
Post %	1.52	1.52	4.55	28.79	63.64	N=66	4.52

Table 3

Student proportions for personal category questions (significance highlighted).

	1-SD	2-D	3-U	4-A	5-SA	Total	Average
Science is interesting.							
Pre %	2.07	9.66	12.41	41.38	34.48	N=145	3.97
Post %	3.03	4.55	13.64	37.88	40.91	N=66	4.09
Science is fun.							
Pre %	2.05	8.90	16.44	51.37**	21.23**	N=146	3.81
Post %	1.54	3.08	21.54	35.38**	38.46**	N=65	4.06
I like to study science in school.							
Pre %	6.85	10.96	28.08	33.56	20.55**	N=146	3.50
Post %	4.55	6.06	27.27	27.27	34.85**	N=66	3.82
I like to learn about science.							
Pre %	3.42	9.59	21.23	43.15	22.60**	N=146	3.72
Post %	6.15	4.62	16.92	35.38	36.92**	N=65	3.92

The data from Table 3 indicate a shift in opinions toward strongly agree for personal enjoyment of science. For each question except “science is interesting,” students showed a significant change in the proportion of responses for 5-strongly agree. Though many of the shifts were in a positive direction, students who participated in RET curricula did not always demonstrate this trend. Close analysis, though not significant by measure of the 2 proportion Z-test, indicates that some students actually liked science less, though this is a small percentage. For example, the "I like to learn about science" question shows that the proportion of students reporting a 1-strongly disagree actually increased from pre-survey to post-survey. The same type of result, albeit smaller, is shown for the question, "Science is interesting."

Table 4

*Student proportions for relational category questions. Statistically significant shifts from pretest to posttest are highlighted and denoted as **.*

	1-SD	2-D	3-U	4-A	5-SA	Total	Average
I think that scientists are normal people.							
Pre %	3.42	4.79	22.60**	44.52	24.66**	N=146	3.82
Post %	3.03	4.55	10.61**	42.42	39.39**	N=66	4.11
I have met a scientist.							
Pre %	8.16	6.80	22.45**	34.69	27.89**	N=147	3.67
Post %	3.03	10.61	7.58**	30.30	48.48**	N=66	4.11

The results of Table 4 are an important component of this study; with the researcher hypothesizing that there would be an overall increase in positive relational perceptions of scientists. Though this particular facet of the study is explored in the qualitative component of the survey, the two items in Table 4 offer some indication of how students changed. Students shifted their opinions of scientists being normal people in a positive direction. The shifts occur between the 3-unsure category to the 5-strongly agree category. This is not necessarily to say that students who ranked 3 on the pre-survey ranked a 5 on the post-survey, but rather students showed an overall trend toward strongly agree.

Table 5

*Student proportions for career category questions. Statistically significant shifts from pretest to posttest are highlighted and denoted as **.*

Rating	1-SD	2-D	3-U	4-A	5-SA	Total	Average
I could become a scientist.							
Pre %	15.75**	14.38	23.29	27.40	19.18**	N=146	3.20
Post %	3.03**	13.64	12.12	30.30	40.91**	N=66	3.92
I would consider pursuing science as a career.							
Pre %	16.22**	18.24	25.68	24.32	15.54**	N=148	3.05
Post %	4.55**	13.64	21.21	30.30	30.30**	N=66	3.68
I would attend a summer science camp or research internship.							
Pre %	32.19**	16.44	30.14	12.33	8.90	N=146	2.49
Post %	15.15**	21.21	33.33	13.64	16.67	N=66	2.95

Proportions of the sample demonstrated shifts in perception for all three of the survey items in the career, therefore supporting the researchers hypothesis about improved science career perceptions (Table 5). Student survey results show that a significantly smaller proportion of students 1-strongly disagreed they could become a scientist, would pursue a career in science, and would attend a science summer camp or research internship. A significantly larger proportion of students reported 5-strongly agree for becoming a scientist and pursuing science as a career.

Response Difference Between Genders

Although not a central component of the researcher's original hypothesis, data analyses have indicated some interesting differences. Emergent knowledge during the analysis prompted a birds-eye look at the data. It started by noticing more drastic differences from pre to posttest for females. This trend was subjected to a t-test for each question, with a t-test comparing pre to post for each gender, where for males, n= 27 & 53 for posttest and pretest, and for females n=35 & 89. The data are presented in Table 6.

Table 6

*Male/female pre-survey and post-survey means comparison. Statistically significant data (p<.05) as determined by t-test are denoted *.*

Question	M-post	M-pre	Difference	F-post	F-pre	Difference
1	4.41	4.36	0.05	4.63	4.40	0.23
2	4.48	4.30	0.18	4.54	4.31	0.23
3	4.19	3.79	0.40	4.37	3.95	*0.42
4	4.56	4.34	0.22	4.77	4.38	*0.39
5	4.56	4.45	0.11	4.57	4.37	0.20
6	4.19	3.94	0.25	4.14	4.01	0.13
7	4.07	3.90	0.17	4.09	3.78	0.31
8	3.93	3.62	0.31	3.89	3.51	0.38
9	4.07	3.75	0.32	3.91	3.74	0.17
10	4.07	3.94	0.13	4.26	3.83	*0.43
11	4.15	3.75	0.40	4.14	3.57	*0.57
12	4.00	3.25	*0.75	3.91	3.20	*0.71
13	3.63	3.13	0.50	3.83	3.06	*0.77
14	2.89	2.38	0.51	3.17	2.61	*0.56
Averages	4.08	3.78	**0.307	4.16	3.76	**0.393

** t-test: statistically different by p<.0001, t=-87.14

Females demonstrate more significant difference in pre to post, especially for questions in the career category. To see if there was a larger difference in response tendencies, all samples were compiled, averaged, and then the average difference between those samples was calculated. A t-test was used to compare that difference between genders, as shown in Figure 5.

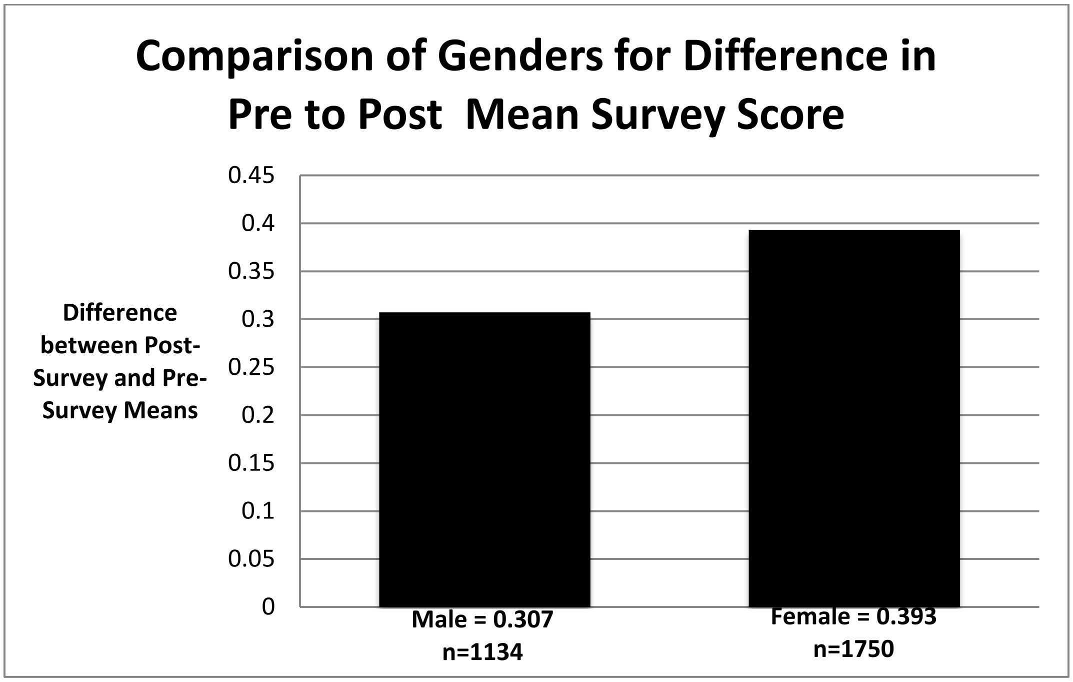

Figure 5. This is a comparison of male and female average difference from pretest to posttest. Data are statistically significant by $p < .0001$, $t=87.14$.

Collectively, the data demonstrate female students increased their average survey response scores more consistently than male students. This is not, however, the only interesting phenomenon present in the gender comparison data. Data analysis led to noting a difference in the variance (or standard deviation) in answers for males and females, as presented in Table 7. Though not speculated in the original hypotheses, these results provide fruit for discussion and potential future studies. Answer clusters are presented as raw standard deviation scores for the means of each survey question. Female and male pre and post question standard deviations are presented to demonstrate these differences. Smaller standard deviations are observed for many of the female responses, indicating less variability within the sample.

Table 7

Male/Female standard deviation comparisons

Question	Male SD pre	SD post	Female SD pre	SD post
1	0.83	0.95	0.67	0.59
2	0.77	1.00	0.73	0.65
3	0.94	0.98	0.97	0.68
4	0.85	0.96	0.66	0.42
5	0.74	0.96	0.76	0.60
6	1.03	1.16	1.01	0.72
7	0.97	1.12	0.88	0.74
8	1.19	1.25	1.06	0.92
9	1.08	1.21	0.98	0.98
10	0.86	1.12	0.94	0.73
11	1.10	1.27	1.24	1.02
12	1.36	1.25	1.31	1.08
13	1.35	1.25	1.27	1.03
14	1.36	1.34	1.24	1.13

Free Response Question Results

The student survey included three free response questions, and the researcher categorized student responses for each question (Tables A1-A7). The researcher created categories in an emergent fashion, where the researcher first read all survey responses and created categories while doing an initial analysis. Further repeated analyses involved paring the categories down until only a few remained for each question. For the question, “What do scientists look like?” student responses were categorized as normal human, neutral stereotype, and nerd or geek (Tables A1-A3). Student answers were partitioned into one category each and answers that did not apply or were unrelated to the question were omitted from analysis. The researcher then compiled pre and posttest results and compared them with a 2-proportion Z test (95% confidence interval) to determine pre to post differences (Figure 6).

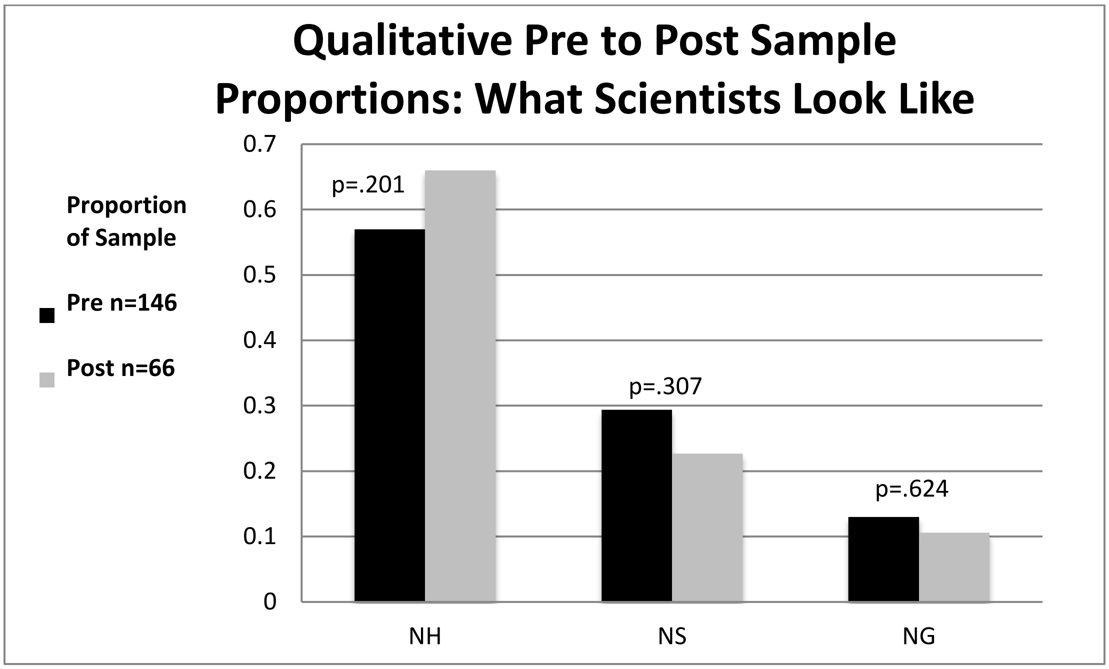

Figure 6. This is a comparison of pretest to posttest categorical proportions for NH (normal human), NS (neutral scientist stereotype), and NG (nerd, geek). P values for a 2-proportion Z test are shown for each grouping.

Results show modest differences from pre to post for each categorical grouping, with no statistically significant differences reported. Despite this, trends toward recognizing scientists as normal people and moving away from negative stereotyping of scientists were considered favorable by the researcher. A similar analysis took place for the question, “Where do scientists work?” Student responses were placed categorically in groups titled “anywhere” and “in a lab.” Results were further filtered by pre and posttest categories and a 2-proportion Z test (95% confidence interval) was used to determine if a significant shift occurred (Figure 7).

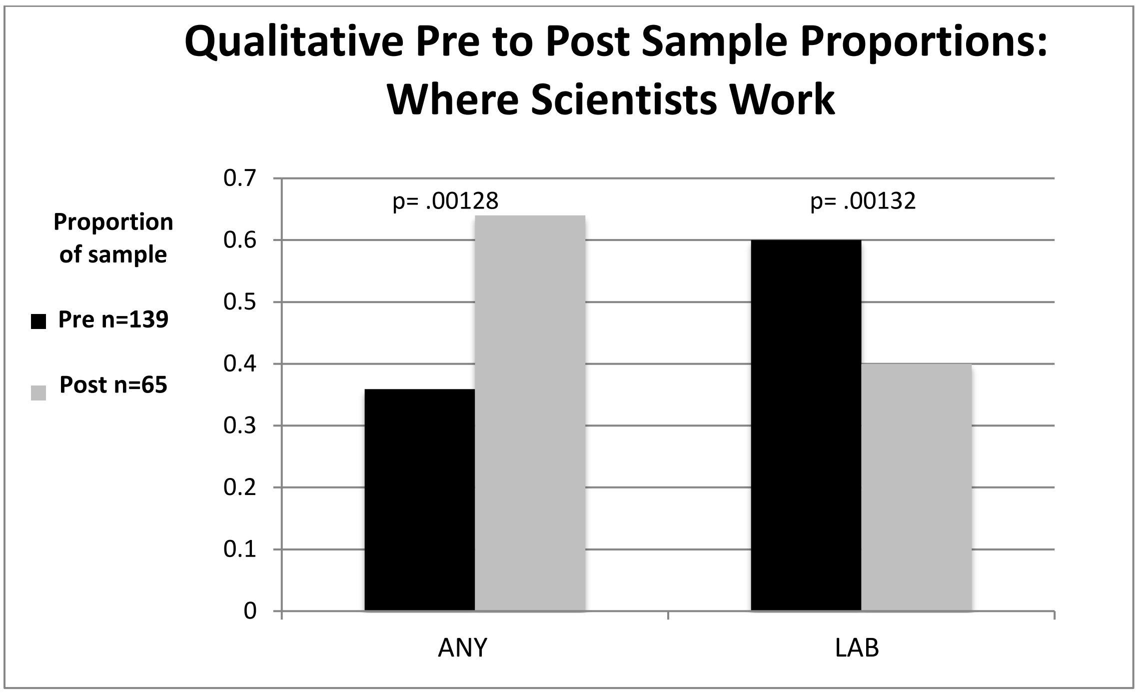

Figure 7. This is a comparison of pretest to posttest categorical proportions for ANY (anywhere) and LAB (in a lab). P values for a 2 proportion Z test are shown for each grouping.

A statistically significant difference pre to post was observed for both groups. The shift, from students reporting mostly that scientists work in a lab to scientists working anywhere, was considered favorable by the researcher. This shift demonstrates that students have a better understanding of the wide variety of scientific work, and that the performance of this work occurs in a multitude of settings.

The researcher created three categories for the final question, “What do scientists do?” Categories were “help or make things better,” “science or science process,” and negative stereotype such as “make bombs, create explosions, blow things up, or evil science activities.” These categories were analyzed pre to post using a 2-proportion Z test (95% confidence interval) to determine if any significant shifts occurred (Figure 8).

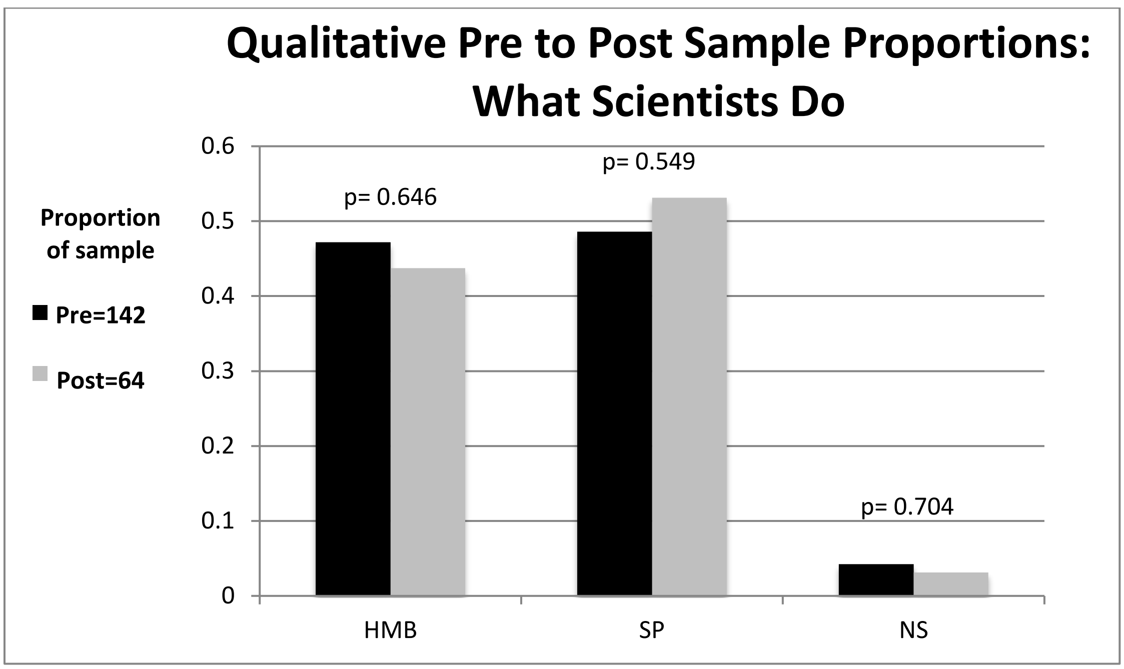

Figure 8. This is a comparison of pretest to posttest categorical proportions for HMB (help, make better) and SP (science process), and NS (negative stereotype). P values for a 2-proportion Z test are shown for each grouping.

No significant differences were observed for any of the categories pre to post. Though no trends were significant, each of the categories did move in a favorable direction according the hypothesized changes.

Teacher Survey Results

A second survey was distributed to the teachers of student participants. The teacher participants ranked their RET curriculum experience according the TSP framework (Figure 2). Teachers were trained in reading and placing classroom partnerships on the TSP framework during their 7 week RET program. Teachers who participated in the survey were able to accurately evaluate their partnerships because they had previously been trained to recognize the different criteria. Results for teachers' analysis of their own partnership are shown below (Table 8).

As evidenced in Table 8, the sample size of teachers for this study was very low. Luckily, these teachers had a large percentage of their students participate, so student data served as a more reliable source of information for research purposes. While it is difficult to draw any relevant conclusions without a larger sample size, it is evident that partnership included much less student/scientist contact than what is considered satisfactory based on the TSP framework. Despite that weakness, many positive trends were present in student survey data.

Table 8

Teacher survey response matrix. Evaluation of Teacher-scientist partnership using the TSP framework that was provided during RET. Teachers used the provided image (Figure 1) and answered the questions. N= number of teacher participants.

For teacher partner interactions, ratings were as follows:						
Option	My work, my time	Focus remains on individual	Design together taught separately	Consensus on instruction	Shared care for student achievement	Total
N=	0	0	3	0	1	4
For program structure, I would rate my partnership as:						
Option	Little contact	Cooperation on lesson plans.	Discrete project.	Sustained project collaboration	Sustained partnerships and school change	Total
N=	1	0	3	0	0	4
For student engagement, I would rate my partnership as:						
Option	Not engage d	Student work with teacher and/or partner engaged	Teacher and partner led instruction.	Social student learning by teacher and partner	Student actively engaged by teacher and partner.	Total
N=	1	2	0	0	1	4

CHAPTER 5

DISCUSSION

Pre to Post Trends

According to the data on student perceptions of science there was a significant difference ($t(2980)=8.203$, $p< .0001$) between the total score averages from pre and post-surveys for students. This data confirms there was an overall increase in students' perceptions of science, but this data doesn't give any information about which category those changes occurred. The researcher divided the responses into categories that closely match up with the original research questions. The research questions for this project were: How does an RET teacher-scientist partnership influence students' (a) feelings about science, (b) perception of the relevance of science in their lives, (c) perception of scientists, and (d) desire to work in a science related career? The four categories that student responses were split into showed a significant positive shift for each, offering support that the RET curriculum helped students increase in their positive feelings about science ($t(1068)=4.084$, $p< .0001$), relevance of science ($t(853)=2.979$, $p= .0009$), perception of scientists ($t(408)=2.981$, $p = .0030$), and desire to work in a science related career ($t(639)=6.261$, $p< .0001$). Although there were increases across the board, we still weren't able to answer the degree to which RET contributed to these changes. Teacher responses were very low in number, and the teacher and student data weren't sufficiently linked. Therefore, while there are net positive increases in perceptions, it is impossible to determine if a good partnership would have caused a greater increase in perceptions as compared to a bad partnership.

Further analysis included proportionality testing to determine where shifts in student opinions about science occurred. Most of the shifts were movements from students being “unsure” about their responses to the “strongly agree” column. Statistically significant results (as determined by 2-prop Z test) were often measured in those two categories. Interestingly, there was a stark difference from pre to post for the “strongly disagree” column for all three of the pursuing science careers questions. Students were much less likely to state they strongly disagreed and they could become a scientist, pursue a career in science, or attend a summer science camp. In other words, students were more likely to report they would engage in these activities. This data trend gets at the heart of what the RET program aims to do for high school students. The program is designed to transform teachers for the purpose of changing their students’ attitudes about science, thus affecting the likelihood students enter science careers.

Though any of the conducted analyses alone would offer marginal support for the researchers’ hypotheses, the researcher used a basic triangulation method to better address the research questions (Cohen, 1998). The first approach was to analyze the surveys from a holistic perspective, taking large sample sizes and assuming some generalizability about the questions. This involved using an unpaired t-test to compare the pre-survey and post-survey responses. This approach indicated statistical significance in every category measured. A second method involved using proportionality testing to see if there were shifts within the data sets associated with each question. This method offered a very detailed look at how the data changed within each question. To use this type of analysis, a normal distribution was assumed because the sample size was large enough at $N > 30$ (Bock et al., 2010). These analyses also demonstrated positive shifts in student perceptions of science. Free response questions were the third component of triangulation implemented in this study to determine if there were changes in student perception of science. These three components are used to strengthen the validity of the findings. It is concluded that students experienced an overall positive shift in perceptions of science and scientists as a result of experiencing an RET curriculum.

Free response questions were offered to all student survey participants. The researcher used an emergent method of analysis to determine categories and then placed responses within those categories. A t-test was used to compare whether there were statistically significant pre to post differences for each of the categories within the survey free response questions. The first question, “What do scientists look like?” showed no significant changes from pre to post. However, it should be noted that each of the data changes trended in a positive direction for science perception. The second question, “Where do scientists work?” had significant differences for both categories anywhere and the lab ($p = .00128$, $p= .00132$). This demonstrates that students’ experience with RET curriculum helped them better understand the wide variety of places scientists can work. It is promising because it shows students are moving away from stereotypes about science and science careers. The final survey question, “What do scientists do?” showed no significant changes and only marginal shifts in the favorable direction for the researcher’s hypothesis. Further work on the qualitative component of the survey instrument could serve to better validate confirmation of the hypothesis, if a repeated study occurred.

Not only do the findings support the researcher's hypotheses, but they also provide for rich discussion regarding the Social Cognitive Career Theory (SCCT). Positive student survey results offer support for students experiencing gains in self-efficacy. Teachers and scientists were encouraged to design work that was challenging and fun. Students also had opportunity to interact with some of the scientists, though 2 of the teachers reported their partner never made contact with their students. Though anecdotal in nature, the researcher recalls each of the teacher participants as being charismatic teachers. These teachers are considered to be capable of verbal persuasion of their students. A final component of self-efficacy within the SCCT model includes the physiological state of the students. There is no real knowledge of the physiological state of the students, which may be dependent on intrinsic and/or extrinsic factors. Even the classroom environment of the students would impact their physiological state. Though some aspects of self-efficacy are left to speculation, the student survey responses offer support for an overall increase in student self-efficacy. Furthermore, interactive agency combines self-efficacy with interpersonal relations, so it can be inferred for most students positive interpersonal relations were created and interactive agency fostered.

Response Difference by Gender

Although no hypotheses about gender differences were proposed at the outset of this study, some interesting relationships have emerged through deeper analysis. The researcher first noticed a pattern by filtering for male and female results and noticing the great differences in standard deviations. Further analysis showed significant differences between male and female related to their science perceptions ($p < .0001$). Though a significant value was determined, this is also just a comparison of a generalized single factor for male and females. To corroborate this finding, further analysis is necessary in future studies, perhaps using a slightly altered survey instrument and a triangulated method of data collection and analysis (Patton, 1999). While the results for differences show variation between genders, difference in standard deviations for the data sets are what originally prompted the gender analysis (Table 7).

The table presenting standard deviations provides some face validity to the assumption that female students may be more impressionable than male students. Notice not only did females experience a greater increase in average scores for pre to posttest, but also had less variability for every response in the survey. While thought provoking, a difference in sample size between males and females could account for the difference. However, both sample sizes were greater than $n=30$, a generally accepted sample size for normal distribution assumptions. In any case, it is suggested that special attention be paid toward these trends in future studies.

Recruiting young women to science careers is an important effort taking place in contemporary society (Handelsman et al., 2005). We face major global challenges in the 21st century, and the act of limiting our societies' problem solvers to a single gender is not only an unnecessary handicap, but also an illogical, unethical approach to upholding values of equality. Despite many academics holding a similar belief, there are still discrepancies with their actions. A study conducted by Yale university involved professors at many other universities. These professors were presented job application materials for equally qualified candidates (male and female) for lab manager and lead science positions. Professors overwhelmingly selected more male candidates from the pool, and the study demonstrated that even among people who claim to reject gender favoritism, a male selecting bias exists (Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsmen, 2012). Many other studies have shown similar trends, and many initiatives to get more women in science related careers have been recently established.

The importance of providing equal opportunity for women scientists and aspiring scientists cannot be overstated. Major issues face humanity and nations need all of the brainpower that can possibly be mustered. This RET study provided some evidence that high school curriculum involving scientist/student association can make a great difference. This difference is seemingly greater for female participants, therefore, evidence demonstrates that RET curricula partnerships and similar efforts should be taking place in high school classrooms as a way to stimulate interest in science careers.

Teacher Response Data Interpretation

There were only four teachers who participated in this study, so interpretive value and implications are limited. However, most teacher ratings were either low or mid-low for the quality of the teacher-scientist partnership. It stands to reason that perhaps student pre to post gains could have been more dramatic if the partnerships between scientists and teachers were significant and longer lasting. Alternatively, there is a possibility that student gains have nothing to do with the teacher-scientist partnership. It is also noteworthy that all of the teacher participants were male teachers. It is unknown if this has any impact on the sample, so future studies should include some filtered analysis to determine if teacher gender has any affect RET curriculum efficacy, with special attention to gender-specific changes. At the outset of this study, the intention was to correlate student pre to post survey differences with teacher TSP rankings. With such a small sample size of teachers the differences seen would not have been significant, so no additional analyses were performed. Future researchers need to include a large enough sample size of teachers to provide meaningful correlative statistics to the two survey instruments.

Implications for Partnership and Curriculum

The results of this study have implications for normal high school class curriculum and RET program efficacy. First, results indicate when students experience a robust inquiry curriculum there is a positive impact on student perceptions of science. It is not certain if student contact with scientists facilitates this trend. A science teacher need not be admitted to an intensive 7-week research internship to make such a difference in the classroom. Nearly every community has some type of scientist working nearby. If a research chemist, physicist, or university biologist is not within driving distance, perhaps a doctor or nurse is in proximity. Professionals can establish collegial relationships to consult on curriculum development and perhaps schedule a classroom visit or something more longstanding. The RET model is one example of a way to get scientists into the classroom and in contact with students, but it is not the only model. Many hospitals, biotech companies, food companies, or agricultural industries offer shadowing and basic job opportunities for high school students. These organizations are often happy to participate in some type of educational outreach as well. It is up to the teacher to initiate the relationship and hopefully groom what can become a partnership that yields positive fruits for the students.

Data in this study made clear how quickly stereotypes and negative attitudes about scientists and science careers could be dismantled. Two-proportion Z-tests performed on each question demonstrated large shifts away from “strongly disagree” categories in many different circumstances. It is important that students communicate with a real scientist, engineer, or science-related professional so they can relate to the person. Bandura (1989) describes the importance of vicarious experience and learning when considering agency and the likelihood to perceive success when considering a career. If a student is never given the opportunity to meet and relate with such an individual, this aspect of agency is left out, and student positivity toward science careers is adversely affected.

One area for concern in this research were the rankings teachers provided for their RET partnership. Working with a professional scientist as a full time teacher on such a project can present many challenges. First, time is a limited quantity, and both parties do not want to step over their boundaries. Teachers recognize that researchers are balancing many projects, lab responsibilities, grant writing assignments, and even teaching positions. Couple that recognition with a high school teacher's often hefty workload and it is a recipe for infrequent communication and partnerships not fulfilling their potential. RETs need to encourage and set aside meeting time for teachers and scientists to establish boundaries and contact schedules at the start of the year. There should also be incentives to keep both parties interested. For example, the researcher and teacher could work on a joint publication if their partnership involves some meaningful learning for students.

Limitations and Future Work

This project, like all types of research, is not without some limitations and sources of error. These include a small teacher sample size, a homogenized teacher population, a disproportionate representation from male and female students in the sample, Hawthorne effect, habituation bias, and potential for teacher influence on student responses. For this study, only four teachers participated and all four of them were white men. Due to the homogeneity of the sample, certain skepticism is warranted. Additionally, there were different numbers of responses from male and female participants. This difference has a greater effect when the sample size is small or moderately small. With a sample size a little over 200, there may have been some error introduced due to the gender difference in response rate. Limitation is also warranted considering the difference in pre and post-survey responses. With the size of pre-surveys being nearly three times that of the post-surveys, it is possible that the populations have a different makeup. For instance, what if the proportion of students who have an A in science in the post-group was much higher than that of the pre-survey group? Would this not have an effect on the survey response trends?

Another area for concern is the Hawthorne effect. This is a well established form of data skewing, where participants simply respond better or the way a researcher might want, simply because the participant is part of a study. This effect may have contributed to the gains observed from pretest to posttest, and remains an area of concern for the researcher. Future work could alleviate this problem with a large sample size. If forty teachers or more participated in the study, it would be expected that around 2000 or more students would partake. With those kinds of numbers, there could be separate data analysis, where the researcher can take only pretests from half of the sample, and take only posttests from the other half of the sample. The averages of those two groups could be compared to the overall averages and variation measures could inform ways to account for the Hawthorne effect. Habituation bias, the tendency for participants to answer the same way for questions worded in a similar fashion, could work its way into this study. Though the student survey was adopted from a previously validated instrument, one cannot help but notice the similarity in some of the questions presented in the survey. Survey items such as “Science is fun,” and “I like to study science in school,” have the same underlying tone. A repeated study might aim to further modify the instrument so that habituation bias is limited in its effect.

Future analyses could occur in a multitude of ways, but the first recommendation would be to consider the aforementioned changes, as well as to recruit more heavily at the outset of the study. There were not as many participants involved in the study as originally hoped. This study would be more conclusive if there were a larger sample size. Procuring a sample of thirty or forty teachers is feasible, as many RETs or teacher work experiences have a few dozen participants. With a greater and more heterogeneous sample, meaningful relationships may stand to corroborate or extend the findings presented here. Though this study has some weakness, an overall positive increase in students' perceptions of science and scientists was shown to be statistically significant and further validated through triangulation. These findings are encouraging because students can experience gains in agency, and come out of such a curriculum with an increase in confidence. Efforts such as these are what will push society forward and help to address the challenges humanity faces in the 21^{st} century.

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APPENDIX A

STUDENT SURVEY CONSENT AND ASSENT

PARENTAL CONSENT: This study is designed to evaluate the effectiveness of your child's science teacher's curriculum developed during the Iowa State Research Experience for Teachers. It is being conducted through the University of Northern Iowa and Iowa State University. Students will be asked to state how much they agree or disagree with a series of statements about the science, scientists, and science as a career. Participation in this research is easy, and requires only the filling out of a short online survey that will take less than 10 minutes. There are no foreseeable risks to taking this survey and participation is voluntary. There are possible benefits of taking this short survey. The results will be useful start up discussion on science as a career among parents, teachers, and students. Not only that, but also this survey will help with teacher professional development programs across the nation, thus potentially impacting thousands of students. This survey is not a part of the science curriculum and students will take the survey at home. All surveys and data will be anonymous and no personally identifiable information will be collected. The summarized findings with no identifying information may be published in an academic journal or presented at a scholarly conference. Your child's participation is also completely voluntary. He or she is free to withdraw from participation at any time or to choose not to participate at all, and by doing so, your child will not be penalized or lose benefits to which he/she is otherwise entitled. **I am fully aware of the nature and extent of my child's participation in this project as stated above and the possible risks arising from it. I hereby agree to allow my son/daughter to participate in this project.**

- Yes, I allow my child to take this survey
- No, I do not want my child to take this survey

STUDENT ASSENT: I have been told that my mom, dad, or the person who takes care of me has said that it is okay for me to take part in an activity about my attitudes towards science. I am doing this because I want to. I have been told that I can stop my part in the activity at any time. If I ask to stop or decide that I don't want to do this activity at all, nothing bad will happen to me.

c. Yes, I want to take this survey

d. No, I do not want to take this survey

Student Survey Questions:

1. Please enter your teacher code here _____
2. What is your gender?
    a. Male
    b. Female

3. For the following questions, rate your level of agreement with the statement. 1= Strongly Disagree, 2=Disagree, 3=Unsure, 4=Agree, 5=Strongly Agree

4. Scientists use tools and technology to help people and animals

    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure
    d. 4 Agree
    e. 5 Strongly Agree

5. Science helps keep people healthy.
    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure
    d. 4 Agree
    e. 5 Strongly Agree

6. Science affects everyone, including me.
    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure
    d. 4 Agree
    e. 5 Strongly Agree

7. Science can help make our lives better.
    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure
    d. 4 Agree
    e. 5 Strongly Agree

8. Science is interesting.
    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure
    d. 4 Agree
    e. 5 Strongly Agree

9. Science is fun.
    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure
    d. 4 Agree
    e. 5 Strongly Agree

10. I like to study science in school.
    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure
    d. 4 Agree
    e. 5 Strongly Agree

11. I like to learn about science.
    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure
    d. 4 Agree
    e. 5 Strongly Agree

12. I think that scientists are normal people.
    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure
    d. 4 Agree
    e. 5 Strongly Agree

13. I have met a scientist.
    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure

d. 4 Agree
e. 5 Strongly Agree

14. I could become a scientist
    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure
    d. 4 Agree
    e. 5 Strongly Agree

15. I would consider pursuing science as a career.
    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure
    d. 4 Agree
    e. 5 Strongly Agree

16. I would attend a summer science camp or research internship
    a. 1 Strongly Disagree
    b. 2 Disagree
    c. 3 Unsure
    d. 4 Agree
    e. 5 Strongly Agree

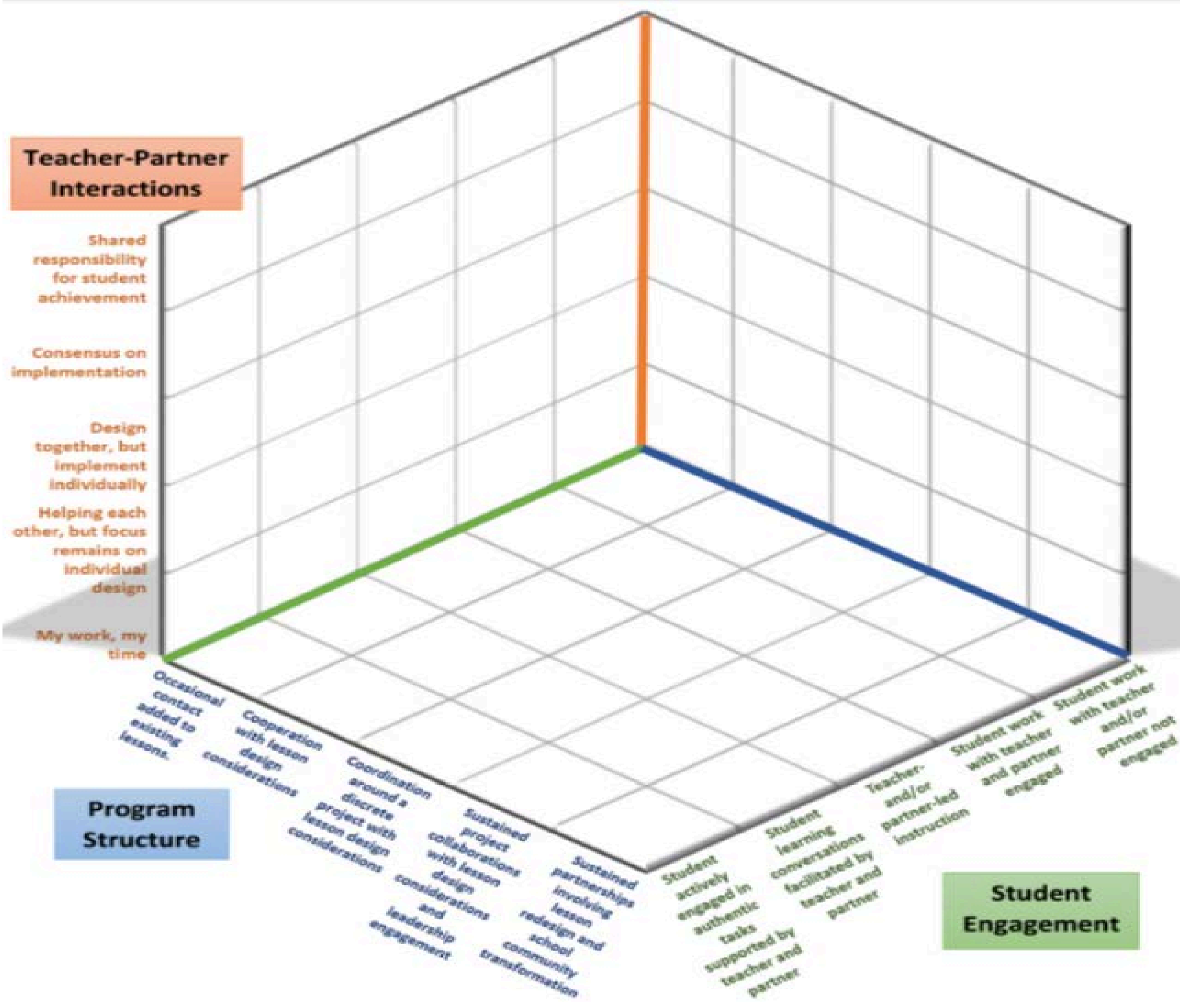
Free response questions:

17. Please describe what a scientist looks like: _____________
18. Please describe where a scientist performs their work: ____________
19. Please describe what a scientist does: ____________

APPENDIX B

TEACHER SURVEY

1. Please enter your teacher code here _____
2. What is your gender?
    a. Male
    b. Female
3. For this survey, you'll be evaluating your Teacher-scientist partnership using the TSP framework that was provided during RET. Please use the provided image and answer the following questions. Thank you very much for your time to participate in this study!



4. For teacher partner interactions, I would rate my partnership as:
    a. 1. "My work, my time"
    b. 2. Helping each other, but focus remains on individual design
    c. 3. Design together, but implemented by myself
    d. 4. Consensus on implementation
    e. 5. Shared responsibility for student achievement
5. For program structure, I would rate my partnership as:
    a. 1. Occasional contact with scientist and I added to existing lessons.
    b. 2. Cooperation with scientist in lesson design considerations.
    c. 3. Coordination around a discrete project with lesson design considerations.
    d. 4. Sustained project collaborations with lesson design considerations and leadership engagement.
    e. 5. Sustained partnerships involving lesson redesign and school community transformation.
6. For student engagement, I would rate my partnership as:
    a. 1. Student work with teacher and/or partner not engaged
    b. 2. Student work with teacher and/or partner engaged
    c. 3. Teacher and partner led instruction.
    d. 4. Student learning conversations facilitated by teacher and partner.
    e. 5. Student actively engaged in authentic tasks supported by teacher and partner.

7. Please indicate yes or no if your students made contact with your ISU research mentor or PI
    a. Yes
    b. No
8. How many occasions did your students make contact with the ISU researcher during this fall semester? __________

APPENDIX C

QUALITATIVE SURVEY RESPONSE TABLES

Table C1

"What does a scientist look like? (category: anybody)

Responses classified as "normal human or anybody".
Anyone can be a scientist; therefore a scientist can look like anyone. If we are strictly speaking about people who are legally referred to as "scientists" (people with a proper college education, specialty in the field, and are paid to be a scientist), then they would most likely look in their early/mid-twenties.
They can look like anything.
A man or woman researching and attempting to learn or create something new and beneficial to the world.
Anyone around me
A scientist can be anyone who loves the scientific avenue, learning and exploring science.
Nothing particular. A scientist could be a woman or man, any age or race. A scientist could also be found in many different career fields.
A science could wear a lab coat or wear casual clothes
A very smart person who knows how the world and most things around them work.
Like any other person
Someone who cares about a cause and tries to work towards a goal.
They look like every other person in the world.
A scientist looks like a normal person. They got a face, some arms and legs. Brain. Sometimes they wear a lab coat and goggles.
Like a human being.
It can look like anyone in the world
science looks like people come together to help solve a problem
A scientist could appear however they would want to, but in order to be a scientist, they must be studying something
They are usually human, can wear a lab coat or polo, are generally smart, and make the six digit income.
A person that has had a formal education and wears a lab coat or another form of uniform.
A scientist can be anyone in any shape or size.

(table continues)

A scientist is a normal person with a scientific degree. Scientists pretty much wear everyday clothes, and they sometimes where lab coats and goggles if they are in the lab.
A scientist looks like every other person.
A normal person
normally in a lab coat but just like a normal person
A human
A normal person wearing a lab coat.
A scientist could be anyone
Average person, but a much more professional look. Maybe something formal.
Man or woman attempting to advance society
a normal type person who just works in a lab.
A scientist can look like anyone. There is no requirement for what a scientist can act or look like.
like a person because anyone and everyone can be a scientist. the only difference is these people usually have a lab coat and goggles.
A scientist can be dressed in pretty much everyday clothes. It doesn't really matter what they look like because not every scientist is the same.
Anyone that studies science
A scientist is an everyday person
A scientist looks like an ordinary person. Scientists can look like anything considering that there are all kinds of scientists that work in different fields.
Anybody
Anybody that does good in the world in order to make it a better place.
A scientist looks like everyone else. They have 2 eyes, some hair, an arm or two, two legs, a nose, some teeth.
anyone and everyone
like look like normal people on the outside but in the mind they are different. because in their mind they are thinking and thinking, about what can the do to help advance the world.
Like every other person
Everybody can be a scientist
Mr. McCutchan.
Exploring new things like germs and doing experiments
A scientist looks like a normal person and wear a white lab coat as well as goggles.
a person
A scientist is any person that studies science, no matter what they look like.
A normal person, that does normal things
anyone in this world.
(table continues)

person in a lab coat and goggles, or a regular person
It is person that has a degree that to pursue bettering the world.
Like a human being
An interested person
A scientist can be literally anyone. Technically we are all scientists. We are constantly reconstructing different methods of going about things.
A scientist is any normal human being with the same traits and characteristics as any other person in a career.
A scientist can look like anything and can be in a wide range of jobs, and help the community in many different ways.
Anybody can be a scientist so there is no designated appearance outside of commonly conceived stereotypes.
A homosapien sapien.
Normal looking person
Anyone can look like a scientist. Depends on what you are a scientist of.
A person?
Any one els. Average
Anyone who has a desire to learn and explore different things about any type of atmosphere, for example, biosphere, cryoshpere etc
Anyone
A normal person
scientists are normal-looking people
a person
A normal human being
Someone who is really smart, and good at solving a remarkable math question.
Like a person
It could be anyone
Smart
Looks like a person with a lab coat
It's a normal person who looks at things differently
Normal people
Interesting and fun
Like a human being
a person
intelligent
Could be anyone really, in a lab they have goggles, white lab coat, glasses sometimes depending
Normal people
(table continues)

Anyone
People
Normal person
I think a scientist looks like any normal person.
Looks like any other human being.
A normal person.
Any normal person. They can be any gender, race, and personality type
A normal person
Normal people
They look like a human being.
Someone interested and works in the science field
A person
A normal person
Could be anything
Any other person in the world
Like a person? If I had a lineup of random people I probably couldn't pick one out.
Anybody can be a scientist, therefore a scientist doesn't have a set description.
A scientist can look like anyone. A scientist is a person.
A scientist can be anybody
Anything a scientist can be described in several different ways from anything in between. Graham Hicks has a doctorate in astrophysics and looks like the modern gym rat.
Regular person, in clothing required by their workplace.
Anybody who actively seeks to to pursue the advancement of knowledge and engage in innovative thinking.
A scientist can be anyone. They don't have to match a physical characteristic.
Like a person
A normal human
A normal person that you could see every day.
A scientist looks like normal person. The only difference is they are really smart compared to others. They posses a lot of knowledge.
A scientist can look like anyone; however, I clicked "agree" on the question asking if they look like normal people instead of "strongly agree" because, while anyone can be a scientist, scientists shape the world.
A normal person.
It can differ a lot
Like a person
A scientist is anyone working for research purposes
(table continues)

A scientist could be anyone. Any physical appearance
Any person who partakes in the forward progress of knowledge for any subject.
A normal person
Like a regular person.
A person
One who specializes in science
Any person could be a scientist they look normal
Scientists are any types of people who are exploring our world. There is no one type of person who encompasses a scientist
Like any other person you see on the street
anything
A scientist can be anyone so they can look like anyone
They can look like anything, but they are someone who probably is constantly fascinated by the world around them
A scientist can be anyone, therefore there is no exact model of what a scientist looks like.
Can be anyone

Table C2

"What does a scientist look like?" (category: neutral responses)

Survey responses categorized as "neutral responses".
a regular person. wears a white coat like a doctor.
Lab coat, beakers, goggles
A guy with glasses and a lab coat.
Someone with a lab coat and glasses
lab coat, goggles
They look like a normal person...with a white coat...
A scientist wears a lab coat, safety glasses, and gloves. They are very intelligent.
Lab coat, formal dress shirt, slacks or skirt (depending on gender), tie or bow tie, or even no tie.
A scientist wears a lab coat, safety glasses, and gloves. They are very intelligent, curious, and ask a lot of questions.
white lab coat, smart
lab coat goggles
(table continues)

white lab coat and glasses
They wear lab coats and goggles.
A dude with glasses in a lab coat.
labcoat and glasses
They wear a lab coat and goggles
Your normal people but in white coats and with glasses.
a person with a lab coat
A scientist looks like a regular person who tests a hypothesis in a lab coat with safety goggles.
A scientist can look like anybody; male or female. They wear a lab coat and goggles
a person in a lab coat
A person in a labcoat or just a normal person who's doing scientific things
people in a lab coat and work in labs
White lab coat and glasses
mr anderson
smart
lab coat gloves goggles
lab coat gloves and glasses
Mr. Anderson
me
A normal person that is smarter than most people
A person with goggles and a lab coat
A person working with lots of different matireals.
Goggles lab coat
Nearly people in lab coats
Someone smart with a lab coat and beakers full of chemicals
A person in a lab coat wearing goggles and gloves working with chemicals or technology.
Scientist looks like a person either a boy or girl with a lab coat
A scientist can be a man or a woman. They usually wear goggles and gloves to protect themselves while doing experiments. They also use lab coats and sometimes apron to protect their clothing, woman with long hair usually put it up with a hairband.
something explain by science
lab coat and a person
Glasses lab coat and black pearl shoes
Mind blowing
Lab stuff safety stuff
(table continues)

They were lab coats, and goggles. Could look like a normal people
Man/woman with a lab coat
Glasses lab coat
Lab coat Glasses
Smart
A scientist is usually someone that is in a lab coat and usually always doing experiments.
people with lab coats
Scrubs and a white lab coat with rubber gloves on
A scientist would probably be wearing a white lab coat along with gloves and some goggles. I also see them as clean cut and in good shape. I'm not sure why being in good shape would matter but that is what I see.
Someone who wheres a lab coat and works in a lab
A person with a white lab coat with latex gloves and safety goggles
person with a lab coat
Lab coat, goggles
They where lab coats

Table C3

“What does a scientist look like?” (category negative stereotype)

Responses categorized as a potentially “negative stereotype, nerdy, or geek.”
Bald and with a lab coat
When I think of a scientist I think of them having a lab coat on. I also think of them being really smart and looking like Albert Einstein.
Glasses, lab coat, Einstein hair
some old, excentric person in a lab coat
Lab coat or other nerdy clothing
Einstein
always wears a lab coat, normally geeky people
White puff-fro, lookin lil crazy, sick lookin lab coat, probably sippin on a coffee due to not sleepin for days.
A scientist looks like a person with a white lab coat holding beakers with crazy white hair.
(table continues)

bald, science lab coat
A scientist looks like someone with a lab coat and someone that kind of looks like a Albert Einstein
A normal person with a lab coat and crazy hair
Lab-coat, crazy hair, goggles, always working, in a lab at all times
nerd
An old person wearing a lab coat.
Ablert enstein hair, Big glasses
wears a lab coat, typically male, glasses, has googles on
lab coat nerdy goggles
has a lab coat, wears goggles, are nerdy looking.
albert
nerdy guy in a labcoat
A person that looks like Einstein
Old
albert
White
Pale person in a laboratory coat, with goggles.

Table C4

"Where does a scientist perform their work?" (category: neutral stereotyped response)

Responses including lab or stereotyped response.
In a lab
In a lab.
in a lab or special room
In a lab
In a lab or workspace
In labratory
Scientists work in labs or schools, universities.
In a lab
labratory
In a lab
A lab?
Laboratory
a lab
(table continues)

Laboratory.
in a lab or department
in a laboratory
laboratory
A laboratory
In a lab where they are employed.
A lab, or office
In a lab or work area
Laboratory, university or college, and government funded building.
In a lab
in a lab
lab
In a lab.
in a lab
In a lab
In a labroatory
in a lab of some kind
in a lab
At a lab
In a lab or university.
At a lab
In a laboratory.
A lab
lab
in a lab
lab
in a lab
An evil lab
In a laboratory
in a lab or a classroom
in a lab
a lab
in a labratory
Experiments that include the scientific method.
In a lab
In a lab
a laboratory or research center
In a safe Labratory
In a lab
a lab
lab
(table continues)

science lab
lab
a lab.
science lab
labs
Lab Work
lab
laboratory
In a laboratory.
In a lab
In a lab or office.
In a science lab with proper equipment
In a lab
In a lab
Lab
in a labratory with test tubes and other stuff around them
In a lab with chemicals and fire and safety protection
In a lab with chemicals or a bunch of computers and technology.
Experiments
In a lab
In a high strong performing lab.
In their lab
somewhere in the laps
Science labs
in a lab
labs
In a science lab
A lab
Lab coat,goggles,gloves
Labs
A lab
Science lab
Lab
Lab
Lab
In a lavatory, where they perform experiments
They do it in a lab or at a home
Laboratory
In a lab
In a lab
In a lab or outside
(table continues)

In a lab.
in a lab
A lab.
In a lab, perhaps in an office setting when concluding results
In a laboratory
A lab
Labs, office
In a lab
in a labratory
In a lab
in lab or where the thing is he is researching
Their work, research lab
Lab
College universities in a lab
In a lab setting or possibly a classroom
In a laboratory.
Office, lab
A lab or an office of somesort
In a laboratory
Lab

Table C5

"Where does a scientist perform their work?" (category: anywhere)

Responses including anywhere.
It depends, particularly on the branch of science they choose to peruse. For example, you probably won't find an astronaumer studying the moon at the bottom of the ocean. However, some "types" of science could be studied nearly anywhere. For example, a botanist could perform their work almost anywhere (on Earth) because plant life thrives in nearly every continent/condition.
A laboratory. Everywhere. The world is their playground
science can be preformed anywhere and everywhere.
It could be anywhere. They have to be researching the why things are the way they are.
making medicine solving out how to get rid of a disease
A scientist can perform their work outdoors, in a classroom, in a laboratory, or even at home.
area 51.
(table continues)

Scientists work in a lab or outside somewhere, in an outdoor classroom kind of environment.
A scientist can perform work pretty much anywhere. Some scientists perform work in a science lab.
In labs, outside, everywhere
A scientist can work anywhere. Scientists commonly work in labs, but they can also work in an outdoor classroom type of environment.
Where ever they work out whether it be in a lab, office, or the outdoors, or any combination thereof.
Scientists usually perform their work in a lab.
A scientist could wear anything from a lab coat to a suit
Government funded buildings.
Anywhere that helps them advance their observations or test their hypothesies
a scientist usually performs their work in a labratory
A scientist usually performs his/her work in a lab.
Scientists usually perform their work in a lab, or where their experiment takes place.
A scientist can perform their work anywhere, although most conduct research in a lab.
scientist can do many things so there isn't one specific thing that a scientist performs at work.
Scientist can perform their work in a classroom, lab, or even a doctor's office.
anywhere
Scientist work everywhere.
A scientist performs their work in any type of environment. This environment could be anywhere from outside to inside, warm climates to cold climates, and high-tech labs to poor classrooms.
Everywhere... and labs
Everywhere
Science can be performed anywhere
they can perform their work anywhere
they preform their work anywhere and everywhere
outside, inside, in a lab, out in nature, anywhere
Lab, kitchen, outdoors
Labs, companies, classrooms, and other places
science things
Whatever their job includes
Where a they needs to do their experiment or thinking
A scientist could perform their work anywhere from a field to a laboratory. Anywhere they choose to carry out their studies.
Wherever the research is to be done.
A scientist can perform their work anywhere. A laboratory, a school, a hospital, etc.
(table continues)

A scientist may do research in a lab or they may teach in a school. They may also work in hospitals or medical centers or research facilities.
I scientist could perform work in many different places, most common might be: lab space or office
Science can be done anywhere, however the tools scientists like chemists, biologists, physicists, etc use are often set up in laboratories.
Anywhere.
Depends. Labs, schools, outside, on a mountain, underground
It depends on what kind of scientist the person is.
Outside or a lab.
Usually a lab
in a lab or anywhere
In laboratories. Or anywhere with a open safe space with little to no issues while working.
Probably in a lab but they could work at home or somewhere private with the proper funding
In a lab or really anywhere
In labs, at home, at work, outside, in the ocean (everywhere)
Lad Outside Inside Anywhere
Anywhere
I don't care
Come up with new medicine and advance technology
Buildings
A scientist usually performs their work in a lab or on a computer.
There are many types of scientists that work in many different places.
Anywhere
In a lab, in the field
They can perform it anywhere.
Anywhere
Wherever is the most efficient
Wherever there field requires them to work lab, outside, ect
We typically think of scientists in a lab, but science can be performed anywhere.
There is no set place a scientist can perform work. It can be outside in nature, in a city, or in a lab to name a few examples.
You can research or do science everywhere
Depending on the field of science that the scientist is in they will be in a type of laboratory for their field. For an astronomist it might be in a star viewing area and a micro biologist in a sterile generic lab setting
In a variety of settings, a laboratory, an office.
(table continues)

In any environment suitable to that persons need to engage in the activities stated above.
A lab of course. Or in a field of some type collecting samples of something to test.
Scientists usually perform their work in labs, but a scientist can work in many different settings.
At their job
They could work anywhere, there are many different scientists.
Anywhere.
A scientist usually performs their work in a lab or on a computer.
A scientist can perform their work in a soybean field, a lab, etc. They work near whatever they are studying.
In a lab or out in a field. Anywhere.
I think they mostly work in labs but there could be other work environments
In any environment that is suitable to their process of partaking in the forward progress of any subject.
Anywhere
Work is done by scientists everywhere
Anywhere
Depends on what type of scientist they are and what work they perform depends on where they do their work
anywhere
A scientist can perform their work anywhere; a field, a laboratory, or a classroom are examples of places that a scientist could work.
In some sort of area or workspace where they can document their work and easily present their ideas in an organized manner to others
A scientist can perform their work anywhere, not necessarily always in a lab.

Table C6

"What does a scientist do?" (category: scientific process)

Responses categorized as "scientific or scientific process".
Scientists study the natural world and question why/how things occur.
Works with any type things around them
Science type work... Usually chemicals and stuff
They use chemicals and natural ingredients to make new reactions and inventions.
Uses tools and experiments to change things or learn.
Creates things
research and experiment to learn more about the natural world
A scientist teaches, invents, or does other activities with science

(table continues)
Researches information about their field of interest.
Science activities
Studies anything and everything and wants to know why things work
They research study and conduct experiments on stuff.
A scientist performs experiments, does research, and analyzes data to support a hypothesis or theory.
Things with math engineering and technology
A scientist performs experiments, gathers results, and analyzed collected data. They use this data to support or deny a hypothesis.
looks at variety of substances and diseases
tests hypothesis
Looks at the world and studies
Works with chemicals.
They discover new things, create new things, and prove things right or wrong.
Research the world around them
They use research and experiment to discover things about the natural world.
A scientist makes medicine and many other things.
study why and how something happens
Study everything
They figure things out!
studies/ research anything and everything
Study the natural world. Test and experiment theories.
Conducts labs, experiments, and more
Science
Reads, learns, study, and occasionally sleep.
Experiments and exploring new things
Science things. SCIENCE RULES!
science
A scientist uses the scientific method in order to study something they want to know more information about.
works with expirements
anyone who is willing to test and then redo and find new things.
Applies the scientific method to determine how and why something happens, or to discover something new.
A scientist does SCIENCE. Which is a whole ton of different things in a variety of subjects, common or esoteric.
studies science and works on experiments
Again it depends. They almost always do differnt experiments and labs
science
mixes chemicals
They experiment on medicine and other things

(table continues)
Does tests to see if a theory is true to expand the knowledge that humans know about different things.
Test different chemicals to preform different tasks
They do experiments and test stuff
Experiment to figure stuff out
Work hard
Tests
A scientist helps find out new things. They try to create new theories and hypothesizes to decide on what should or should not happen. They are still discovering brand new things and they change the world one discovery at a time
Studies in whatever subject they like or are required to study in
they does everything about the earth like plant, animal, trees, and others.
Breaks downs things.
figure out lots of things that involves math
finds new stuff
Tests diffrent things
A scientist comes up with a hypothesis and proves there theory, can study anthing they want to study!
Research different things
Experiments
Science stuff
Experiment
They make stuff with chemicals
Runs test on chemicals
A scientist demonstrates experience concerning things on or out of earth concerning human, animals, rocks, minerals, and as well as anything space related.
Observes things
Scientist stuff and fun stuff
Everything
Science
Study things
They study different things depending on their field of study.
Researches specific subjects to find answers
Science
They study science and conduct scientific studies.
Learn more about science
Science
Study science things, innovate, test hypotheses, speculate
Research on different topics
Research, academic work, experiments, analysis

(table continues)
A scientist applies scientific theories and methods in their work duties daily.
Depending on their specialty they can do basically anything. Chemistry, biology, and physics are broad categories that are examples of of what a scientist could do.
Anything they are learning about and their means to get there
A scientist conducts research for a specific experiment
Makes inferences about the natural world. Tests those inferences through experimentation.
Conduct experiments to prove a hypothesis
A scientist studies anything to do with our universe from tiny animals to the farthest places in space.
A lot of different things
studies and experiments to discover something
Science
Research and test hypothesis
Test a hypothesis through experimentation.
Science
Research and analysis
Science
Learns, researches, and discovers new things
Solves real world problems
Exploring our world
Reaseach on different topics And tries to find more about the topics
anything
A scientist could do anything however they are working towards an end goal.
Studies some sort of aspect of why things are the way they are
A scientist uses the scientific method in order to better understand some concept or problem.
Experiment

Table C7

“What does a scientist do?” (category: help, make better)

Responses categorized as “help, innovate, improve, or make better.”
Scientists study the natural world and question why/how things occur.
He studies the natural world to make our lives better
they make new things.
they try to make things to help better society
Discovers things around the world by experimenting

(table continues)
Attempts to learn or create something new and beneficial to the world.
A scientist helps out with everyday problems. They work to cure diseases and find new medicines. They do so much more than that too.
Uses whatever resources he can find to try and make the world a better place.
Finds new things for our benifit
He or she works towards their goal that they want to achieve.
Uses science to fix things around the world
A scientist figures things out they ask questions and try to find the answer. The solve mysteries and the world's problems. They also make things explode.
Discovers or reenforces the findings of others through the process of the scientific method.
they do experiments with different things to see how they react and change things in the human nature. They try to find out cures for disease, and find different things to help further the mind of things around use along with the body
helps keep people and animals healthy, helps keep track of whats going on in the world, helps figure out future problems that have yet to come, helps bring the people around that world closer and closer to a more advance civilization.
Science stuff. Scientists test, research, and learn about new things that will help society.
They study certain aspects of the world around them either to improve or learn more about that area.
improving the world
A scientist studies, researches, and experiments things to help out humans and animals in their everyday lives.
A scientist works to make new experiments to find things that will benefit the daily life of a human.
A scientist looks for solutions to problems looks for cures for diseases.
Cures diseases, fights diseases, sends people to space, make fake limbs (arms, legs, etc.).
A scientist studies their area interest looking either to advance their area of expertise, or confirm what other have claimed to do.
A scientist tries to better people's lives.
figures things out to make our life better
makes things to better the world
makes our lives better by improving most things
help people
they help to make new discoveries that will hopefully effect the world on a positive scale
Helps to advance society, help people, solve problems, and more.
Makes things to better the world.

a scientist helps people and helps find medicines and cures for diseases. they also research the things that happens in the world
Tries to help people by increasing our knowledge and tech
(table continues)
They create new things and help us by improving things
test and researches new thing to help better us
A scientists tries to help people.
Scientist study different experiments and observational studies to make the world a better place.
A scientist uses experiments to learn about the ways things work and improve medicine, technology etc.
demonstrates testable ideas to make the world better.
A scientist tries to develop new and improved ways to help find cures and make life better.
tries to prove a hypothesis that they make to help others
A scientist is any person that works to try to discover anything that could advance our world as we know it. Scientists can perform experiments, research, publish results, and critique other scientists' work.
Anything to make the world a better place.
they do an area of things that can help and hurt the world
they help advance our world to make it a better place.
works with science to help problems
make things better or different
they work on things like cures for diseases
They help to understand world around them and how to improve or fix something.
Uses his/her knowledge to make the world a better place with science.
A scientist looks at the world around us and makes observations and often wonders why certain things happen. They do a lot of research and they try to discover new things that help or improve society and individuals within the society.
I scientist uses math, science, and technology to make no discoveries, further knowledge, and help people
They observe the world around them, ask questions, come up with ideas, and try to find solutions to problems.
Discover new stuff
Discover new things that can help the people of Earth
Experiments and develops new technology and medicine and other things like that.
figures out how to make chemicals to help people and the earth
help people
does experiments, tests, helps develop things.
finds cures or makes new combinations
help people

They figure out the the current issues in the world. (Diseases, Environmental issues,issues with the earth)
they study animals plants and they discover new things
Let to make the world better.
(table continues)
Discovers different things about living things, fossils, weather etc
They discover new ways to help people and the way we think.
Discover new things and try to fix things to help others
can help out people. are trying to find cures and solutions for different problems in the world
helps humans or animals in some sort of way
Discovers and creates new things to help people
Scientists work on theorys and create medical supplies and technology to help improve things in the world and create things to help the environment
Scientist's creates new things in the next generation, all the new projects they design or create can go to a professional grade school or something.
Figure out the world and careers for disease and stuff like that mostly everything
help people
Create new things
Discovers or makes.
They do things to improve technology
Helps find cures for sickness or observations
A scientist figures out the best solution to a problem.
They do science to help make lives better.
It is someone who studies something that helps this world
makes discoveries that helps people on a daily basis
They study things and improve life
Solves practical problems
A scientist helps people whether that be with something medical, solving an important problem for flight etc
They study different things in our environment to learn new things about it that could improve our lives.
Works with dangerous chemicals to produce helpful research to advance medical practices and technology
They work to help the world.
They can solve problems, check soil and rocks, or study humans. They do a lot of different things.
A scientist spends their whole life studing something to figure out how to solve a problem or learn about something.
A scientist studies the way the world works so that they can improve it.
Study different animals, plants, laws of science, just anything. They look for solutions, explanations, and even just social experiments.

Science to help advance technology and medicine
Helps people
A scientist researches things to solve problems for our society
Any scientist partakes in the forward progress of knowledge for any subject.

Table C8

"What does a scientist do?" (category: negative stereotype)

Responses categorized as negative stereotype.
blows things up and observes things
Create Frankenstein
scientists lose their minds over things they can't solve. that's what those peeps do.
Research, and try and fail.
nerd things
Makes stuff explode
make nuclear bombs
Depends on what field he is in

APPENDIX D

IRB APPROVAL NOTIFICATION

From: Anita Gordon <anita.gordon@uni.edu>
To: schnekah@uni.edu
Cc: Lyn Countryman <lyn.countryman@uni.edu>
Bcc:
Date: Tue, 26 Jul 2016 11:25:05 -0500
Subject: IRB 16-0293 - Study Approval
Dear Investigator(s):

Your study, Impact of a teacher-scientist partnership on high school students' perception of science, has been approved by the UNI IRB, effective 7/24/16. You may begin recruitment, data collection, and/or analysis for your project. You are required to adhere to the procedures and study materials approved during this review, as well as to follow all IRB policies and procedures for human subjects research posted on the IRB website at http://www.uni.edu/rsp/protection-human-research-participants.

Your study has been approved in the following category: Exempt 1**.**

Your study will **not require annual review or closure**.

If you need to make any changes to your study, you must request approval of the changes before continuing with the research. Requests for modifications should be emailed to the IRB Administrator at anita.gordon@uni.edu.

If during the study you observe any problems or events pertaining to participation in your study that are *serious* and *unexpected* (e.g., you did not include them in your IRB materials as a potential risk), you must report this to the IRB **within 10 days.** Examples include unexpected injury or emotional stress, missteps in the consent documentation, or breaches of confidentiality.

If you need a formal, signed approval letter, contact the IRB office and one will be provided for your records.

Best wishes for your project success.

Anita Gordon
IRB Administrator