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THE IMPACTS OF TEACHER PROFESSIONAL DEVELOPMENT ON PRIMARY GRADE STUDENTS' PERCEPTIONS OF SCIENTISTS AND SCIENCE SELF-CONCEPT

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BY

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ABSTRACT

Negative or stereotypical perceptions of scientists and poor attitudes towards science have deterred diverse populations from entering careers in science (Cheryan, Master, & Meltzoff, 2015; Farland-Smith, 2012). *A Framework for K-12 Science Education* was written as a foundation for national standards in the United States with the vision that a more diverse population of students will pursue science, technology, engineering and math (STEM) careers when they engage in quality science instruction beginning in kindergarten and continuing through grade 12 (NRC, 2011). Realizing a new vision of quality science instruction calls for a systemic shift in teacher preparedness and professional development. This quasi-experimental pretest/posttest research design used a Draw-A-Scientist Test (DAST) to evaluate students' perception of scientists and science self-concept before and after the implementation of a teacher professional development program. The intervention included the participation of one urban and one rural school district with a local university, that provides teacher professional development workshops; resources and materials for science instruction; classroom coaching; and administration support for principals and superintendents. Two coders used a modified DAST rubric to analyze a purposeful sample of 460 drawings from students age 5-8. Inter-rater reliability was established using Cohen's kappa. Perceptions of scientists were identified as traditional, sensational, or progressive. Posttest data show a significant increase in progressive perceptions of scientists including an increase in female scientists, scientists working outside of the traditional lab, and scientists engaging in true scientific practices.

These findings contribute to literature on professional development programs and the importance of beginning science instruction in early elementary classrooms as a factor in changing students' perceptions of scientist and science self-concept, which may influence career aspirations.

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CHAPTER 1

INTRODUCTION

Historically, students' narrow perceptions of scientists and science have deterred diverse populations from entering careers in science (Cheryan, Master, & Meltzoff, 2015; Farland-Smith, 2012). *A Framework for K-12 Science Education* (2011) was written as a foundation for national standards with the vision that a more diverse population of students will pursue science, technology, engineering and math (STEM) careers when they engage in quality science instruction beginning in kindergarten and continuing through grade 12. Quality instruction ensures that students construct their knowledge and can connect learning to their lives and the real world (Hurd, 2002; Osborne, Simon, & Collins, 2003; Portnov-Neeman & Barak, 2013; Shin et al., 2015). Realizing this vision of quality science instruction beginning in elementary school calls for a systemic shift in teacher preparedness and professional development (PD) that involves stakeholders from all levels of the education system (NRC, 2011).

Professional development allows teachers to reflect on their own misconceptions and brings awareness to the importance of perceptions of scientists and attitudes towards science (McDuffie, 2001). Additionally, teachers who feel more confident in constructivist practices tend to hold more positive attitudes towards science teaching and promote successful science learning within the classroom (Finson, Pedersen, & Thomas, 2006). Effective PD can support teachers' pedagogical content knowledge (PCK), impacting their attitudes towards science, which in turn affects students' attitudes towards science and supports classroom instruction that provides opportunities for students to develop a high level of science self-concept (Fishman, Marx, Best, & Tal, 2003; Leibham, Alexander, & Johnson, 2013).

As we face the shift to the Next Generation Science Standards (NGSS) and the realization of *A Framework for K-12 Science Education* (2011), students' perceptions of scientists and science self-concept have been relevant topics for educators and researchers. In fact, negative perceptions of scientists have been correlated to poor attitudes towards science and students' science self-concept (Finson, 2002; Shin et al., 2015). Studies also reported that attitudes towards science and science self-concept contribute to students' decisions to continue in STEM career pathways (Ehrlinger, Dunning, & Devine, 2003; Osborne, Simon, & Collins, 2003). This thesis is designed to examine the impact of a comprehensive teacher professional development program on primary grade students' perception of scientists and science self-concept.

The comprehensive teacher professional development program implemented in this study was the University of Rhode Island's (URI) GEMS-Net project. GEMS-Net uses an evidence-based PD model that incorporates all stakeholders in supporting teachers to continually improve their practice and pedagogical content knowledge (PCK) through collaboration, science content support, and connecting PD to classroom goals and expectations. GEMS-Net ensures that programming aligns to new or updated policies such as the Framework for K-12 Science Education (2011) and the NGSS. GEMS-Net provides PD workshops for all teachers, resources aligned to the NGSS, materials for all science instruction, and building and classroom support including but not limited to, classroom coaching and administration support for principals and superintendents.

In this study, primary grade students' perceptions of scientists will be defined as the perceived image one has of a scientist and the perceived lifestyle that a scientist leads. Science self-concept is defined as the perception of one's competencies in science, the view of who an individual is as a scientist and who an individual is not as a scientist.

Despite the importance of primary grade students' perceptions of scientists and science self-concept there is a lack of literature that focuses on primary grade students (Chambers, 1983). More importantly, studies on the influence of teacher professional development in science education for primary grade students are scarce. Thus, utilizing Gottfredson's (1981) Theory of Circumscription and Compromise, a career aspirations theory, this thesis explores how primary grade students develop perceptions of scientists and science self-concept which may influence career choice. This study will add value to the literature on primary grade students' perception of scientists and science self-concept.

CHAPTER 2

REVIEW OF LITERATURE

Theory of Circumscription and Compromise

Circumscription and Compromise Theory describes how career aspirations are developmental and connect self-concept and career aspirations (Gottfredson, 1981). According to Gottfredson, occupational images, or stereotypes within occupations, lead individuals to make generalizations of the people who hold those occupations. This career aspirations theory can help explain how primary grade students' perceptions of scientists and science self-concept influence career choice beginning at a young age.

Gottfredson described stages of development in vocational aspirations that begin in early childhood (ages 3-5 and 6-8) and continue through adolescents and beyond. Gottfredson (1981) included children between the ages of three and five years old in Stage 1 of her theory. Children at this stage begin to develop a sense that adults are powerful. Young children communicate this knowledge by describing "big vs. little." By age 5, adults are seen as big and they have power in this world. At this age, students begin to see themselves in adult roles and role-play with this dichotomous view. Gender identity forms as early as preschool; often, young children represent themselves as their same sex parent. Kindergarten students are transitioning to the second stage where occupation preferences are developing.

In the current study, the majority of the participating students are situated in Stage 2 of Gottfredson's theory, the orientation to sex roles. In this stage, sex roles in occupations truly begin to develop and children identify behaviors that are "female appropriate" compared to behaviors that are "male appropriate." Children at this age are both dichotomous and concrete in their thought processes. It becomes clear that their career preferences and self-concept often align to their sex identity. For example, the girls in this age group might aspire to be a teacher rather than a construction worker because it is seemingly more gender-appropriate. Furthermore, the first occupations to be eliminated as perceived choices for children in the early elementary years are those that are not seen as appropriate for their gender. Research shows that, for children in our country, scientists are perceived as old, white men (Chambers, 1983; Finson, 2002). If children continue to perceive scientists as an occupation of white men, female children may be more likely to eliminate scientist as an option for them at this early stage. This may translate into excluding STEM college or career choices because as self-concept develops, so does the notion of who one wants to be in the future (Gottfredson, 1981).

Research on this theory shows that once a job/career is eliminated from a person's self-concept, it is rarely reconsidered, and that gender self-concept is the strongest predictor of college pathways and career choices when compromises are made (Henderson, Hesketh, & Tuffin, 1988; Wee, 2014). Cochran, Wang, Stevenson, Johnson, and Crews (2011) used Gottfredson's theory to examine career achievement later in life. They found that adolescent gender and ability predicted career success thirty years later. Addressing perceptions of scientists, especially gender stereotypes, and science self-concept in primary grades may help adolescents to identify with STEM careers. It is conceivable that the primary grades are the most sensitive period to begin addressing gender stereotypes of the images of scientists and science self-concept.

Teacher's Professional Development in Perceptions of Scientists

Students' perceptions of scientists have been researched extensively for over 50 years. Perceptions of scientists have changed little since 1957 when the first study by Mead and Metraux was published (Finson, 2002; Meile, 2014). Many researchers have used the Draw-A-Scientist-Test (DAST) survey tool over the past 40 years with similar results (Meile, 2014). The stereotypical representation of scientists found in the body of research shows scientists as older, white males wearing lab coats and glasses, conducting dangerous experiments using chemicals (Finson, 2002; Meile, 2014). Females are less likely to be depicted as scientists although there has been an increase in female scientists drawn in more recent decades (Chambers,1983; Farland-Smith, 2012; Finson, 2002; Hillman, Bloodsworth, Tilburg, Zeeman, & List, 2014; Miller, Nolla, Eagly, & Uttal, 2018). Furthermore, science is seen as secretive, done alone and may include dangerous acts (Chambers, 1983; Finson, 2002). Hillman and colleagues (2014) found that students' perceptions of scientists are beginning to change with less mythical or magical figures of scientists, although stereotypical images of scientists working in a lab, wearing a lab coat, and using chemistry tools are still consistently drawn in elementary school children.

The classic perception of scientists that is accepted in the field of science education research (Farland-Smith, 2012) has important implications. These images of scientists and lack of diversity in the perceptions of scientists, may affect females and more profoundly (Ehrlinger, Dunning, & Devine, 2003; Finson, 2002). The original study from 1983 using the DAST found that out of 4,807 elementary students, only 28 female scientists were present in the drawings (Chambers, 1983). A more recent study conducted in 2006 by Buldu (2006) found that, in a sample of 30 early elementary students in a metropolitan school in Turkey, no boys and only 5 girls drew female scientists. In another study, Miller, Nolla, Eagly, and Uttal (2018) conducted a meta-analysis of 93 studies, both published and unpublished, that used the DAST. They found there has been a significant decrease in male depictions of scientists although the images are still predominantly male.

In response to the pervasive negative perceptions of scientists and negative attitudes towards science found in the research, interventions have been developed and studied. Many of these interventions are similar in that they introduce students to real world scientists in hopes that perceptions of scientists will change. The results have been mixed. Some studies that introduce female scientists as role models show significant increase in positive perceptions of scientists and positive attitudes towards science in high school students (Smith & Erb, 1986), although Hillman and colleagues (2014) found that this intervention showed a slight negative correlation in perception of scientists in elementary age students. Providing occasional role models has not proven to be sufficient to change perceptions of scientists (Finson, 2002), especially in younger children (Hillman et al., 2014).

In contrast to the Hillman findings, a study by Shin et al. (2015) of a partnership between university scientists and teachers who taught in a 2nd and 3rd grade multi-age classrooms found positive results. In this single sample study, the scientists taught an interactive, center-based, life science unit in the classrooms daily for 6 weeks in two classrooms with a total of 81 students. They found a significant difference in students' perceptions of science, scientists, and science career aspirations after engaging in an authentic and relevant unit of study. These outcomes, however, are based on a limited population therefore the results cannot be generalized to the larger population of public schools across the United States due to the cost and accessibility of scientists as teachers.

Effective professional development (PD) has been proven to broaden perceptions of scientists in teachers (Cheryan, Master, & Meltzoff, 2015; Desimone, Porter, Garet, Yoon, & Birman, 2002; Finson, Pederson, & Thomas, 2006). A longitudinal study conducted by Desimone et al. (2002) found effective professional development engages teachers in active learning opportunities, connects to the goals and expectations of teachers, and focuses on deepening pedagogical content knowledge (PCK). PCK is defined as understanding content specific to a subject area and the teaching practices involved in developing student understanding in the specific domain (Schneider & Plasman, 2011). Additionally, effective professional development includes opportunities for teachers to engage in ongoing collaboration with the objective centered on student learning and growth (Garet, Porter, Desimone, Birman, & Yoon, 2001). Teachers who participate in effective PD report a change in their teaching practices and are more likely to incorporate instructional practices that support student growth and experiences within the classroom (Desimone et al., 2002). There is a relationship between constructivist teaching in the form of "hands-on" science instruction that allows students to construct their knowledge through investigations and the increase in positive perceptions of scientists and attitudes towards science (Finson, 2002; NRC, 2011; Oh & Yager, 2004; Shin et al., 2015). Providing effective PD that engages teachers in developing a constructivist approach to science education may begin to change negative perceptions of scientists.

Research shows that perceptions of scientists and attitudes towards science have been closely linked (Farland-Smith, 2012; Finson, 2002). Unfortunately, many elementary school teachers hold negative attitudes towards science teaching, which perpetuates students' negative perceptions of scientists and influences students' attitudes towards science (McDuffie, 2001). In a study by Denessen, Vos, Hasselman, and Louws (2015) a positive correlation was found between teacher attitudes towards science and student attitudes towards science. Students' positive attitudes towards science decrease significantly when the teacher showed less enthusiasm and felt less competent in teaching science. Students will most likely not choose to enter an educational program leading towards a career with which they do not identify or if they have poor attitudes towards the field of study (Farland-Smith, 2012; Gottfredson, 1981; NRC, 2011; National Science Teachers Association, 1992).

Teachers' Professional Development in Science Self-concept

Teachers and other educational stakeholders have an important and active role in constructing children's self-concept. Self-concept is constructed through everyday experiences and social interactions (Chafel, 2003). Children's sense of identity is influenced and developed through the real world experiences in which they engage (Korn, 1998). Daily science instruction in a collaborative classroom can help build positive science self-concept because students are actively involved in constructing meaning from learning experiences and developing scientific practices and skills (Buck, Cook, Quigley, & Lucas, 2014; Edmin, 2011; Ferrini-Mundy, 2013).

Primary grade teachers often feel less competent in teaching science because they may lack PCK (Murphy, Neil, & Beggs, 2007). Professional development that focuses on PCK should align to teachers' instructional practice and allow teachers to actively engage in, and reflect upon, strategies and materials that can be applied to their own classroom experiences (Van Driel, & Berry, 2015). A study by Meile (2014) of pre-service teachers who engaged in inquiry-based science learning experiences during a science methods course showed a significant decrease in negative science stereotypes. Pre-service teachers in this study drew themselves and students as scientists by the end of the semester, also showing an increase in science self-concept. Addressing PCK in PD may be an avenue to increase positive science self-concept for teachers, therefore instilling positive science self-concept in students.

Academic self-concept describes how children perceive their capabilities in different disciplines and areas of their life (Marsh, 1990). Academic self-concept and academic achievement are related and begin to develop in early childhood (Cohrssen et al., 2016). According to Marsh (1990), children will rank their capabilities by comparing themselves to others. Stereotypes that females are not as good in math and science as males persist (Woodcock et al., 2012) which may lead girls to inadvertently rank themselves lower than boys. In addition to potentially reducing stereotypical images and negative perceptions of scientists and increasing positive attitudes towards science, introducing a comprehensive professional development program that supports teachers in developing instruction that gives all students access to successful opportunities in science may also increase primary grade students' science self-concept.

Gaps in the Literature

Research on comprehensive professional development programs that align to the goals of *A Framework for K-12 Science Education* is limited. While it is posited that beginning science instruction in primary grade classrooms will change student perceptions of scientists and science self-concept and possibly motivate students' related career aspirations (Gottfredson,1981), little research on primary grade science instruction has addressed this hypothesis; nearly all studies look at grades 2 and above (Chambers, 1983; Farland-Smith, 2012). This thesis adds to the literature by identifying how primary grade students' perceptions of scientists and the development of science self-concept might be supported.

Science, technology, engineering, and math (STEM) careers are growing at a steady pace. According to the Bureau of Labor Statistics, STEM-related careers are expected to increase by more than 1,000,000 jobs between 2012 and 2022 (Vilorio, 2014). Unfortunately, many of these jobs go unfilled because students are not choosing, nor are they prepared for, STEM pathways in college (Smithsonian Science Education Center, 2017).

Gender Differences in Perceptions of Scientists and Science Self-Concept

There is an underrepresentation of women in STEM-related careers (Beede et al., 2011). Research on gender differences in science self-concept has been limited (Leibham, Alexander & Johnson, 2013). One study by Ehrlinger and colleagues

(2018) researched gender differences in perceptions of computer scientists and engineers and the relationship between these perceptions and intellectual self-concept. They found that women are more likely than men to hold strong stereotypical perceptions of computer scientists and engineers, seeing them as "geeky" and highly intellectual. Additionally, women in this study reported that they personally feel less similar to the characteristics that they perceive belong to computer scientists and engineers. Although females outperform males on academic assessments in all subject areas (Pomerantz, Altermatt, & Saxon, 2002), women report less confidence in their own intellectual capabilities than men (Ehrlinger, Dunning, & Devine, 2003; Ehrlinger et al., 2018). Women, in the study by Ehrlinger and colleagues (2018), who rated themselves less similar to scientists and engineers were also less likely to be interested in pursuing a career in STEM fields. The current thesis explores differences in gender and can inform the education community on how to better support female students in science education and encourage a more gender diverse population to invest in STEM pathways.

Differences in Rural and Urban Students' Perceptions of Scientists and Science Self-Concept

A difference between urban and rural education has been noted in research on education reform (Lareau & Goyette, 2014). Success in science depends on students' perceptions of how science classes and real-life experiences interact (Aikenhead & Jegede, 1999). Students in urban classrooms show poor attitudes and self-efficacy towards science in elementary school (Buck, Cook, Quigley, & Lucas, 2014). Students from urban schools do not see or hear themselves in science because their communities are not represented in traditional science textbooks and teaching practices are not extending beyond the classroom walls (Bang & Medin, 2010; Buck, Cook, Quigley, & Lucas, 2014; Edmin, 2011; Gay, 2013). Unfortunately, urban science education often continues to use traditional textbook learning and science education can be non-existent in the elementary years (Ferrini-Mundy, 2013). Therefore, it can be argued that the environments in classrooms that use traditional pedagogy are producing negative attitudes towards science for urban populations (Edmin, 2011). A mixed methods study conducted by Freeman and Alderman (2005) explored differences in academic motivation in urban versus rural schools. They found that students in rural schools had stronger motivation to learn because they could connect their education to their lives. Despite the decent amount of studies examining the differences in rural and urban setting pertaining to science education, no study has explored the influence of teachers' participation of professional development on their students' perceptions of scientist and science self-concept. Thus, this thesis will explore differences in perception of scientists and science self-concept between an urban school setting and a rural school setting.

Research Questions

The specific questions are as follows:

1. How do primary grade students' perceptions of scientists differ when teachers are supported by a comprehensive professional development program?

   H1: This study hypothesized that students' perception of scientists will be more progressive when teachers are supported by a comprehensive professional development program. Based on the literature review, the Denessen, Vos, Hasselman, and Louws (2015) study endorses this hypothesis.

2. How does science self-concept differ by student gender at time 2?

   H2: This study hypothesized that there will be no difference between male and female science self-concept. Gottfredson's Theory of Circumscription and Compromise endorses this hypothesis that both female and male students will have a high level of science self-concept when the teachers are supported by a comprehensive professional development program.

CHAPTER 3

METHODOLOGY

Sample

A total of 460 observations came from primary grade students attending two public schools in Rhode Island. This quasi-experimental, longitudinal study used a convenience sample in a pretest - posttest design to quantify the work. There were a total of 15 primary grade classrooms with children ages five through eight. Pretest data (N = 246) were collected from primary grade students, kindergarten through second grade, in the spring of 2015 prior to a professional development program for teachers, the implementation of the Guiding Education in Math and Science Network (GEMS-Net). After the pre-assessment data were collected, GEMS-Net support began in summer of 2015 and continued throughout the 2015-2016 school year. Post-assessments (N = 214) were given to all primary grade students in the spring of 2016. Student data were not paired and individual students could not be identified. Most students participated in both the pretest and posttest although some students only participated in either the pretest or the posttest. For example, the Kindergarten students who participated in the pretest (Spring of 2015) also participated in the posttest (Spring of 2016) when they were in Grade 1, whereas the Kindergarten students who participated in the posttest were not in the sample of the pretest data because they were not in the elementary school in Spring of 2015.

Data source

The secondary data set for this thesis comes from a project that was funded through the Rhode Island Foundation from March 2015 through September 2016. Participants from two Rhode Island Public Elementary Schools were chosen as research sites for the original project because of their expressed interest in joining GEMS-Net. Additionally, the schools were similar in size but different socioeconomically and by locale making them a good choice to explore the impact of a comprehensive professional development program for different populations. Both schools include kindergarten through grade 5. Francis Elementary is situated in a rural setting while Payton Elementary is located in an urban setting. The participants included all consenting students within the educational systems. According to the original study the response rate was 95%. In this study, the two elementary school names are pseudonyms.

Payton Elementary had a population of 297 students, 64% Hispanic, 21% African American, 8% white, 4% Asian, 2% multi-racial and 1% Native American, and 68% of students qualify for free and reduced lunch. Francis Elementary had a population of 265 students, 97% white and 3% Hispanic, with 18% of students on free and reduced lunch. Table 1 describes the sample in this study.

Table 1

Demographic Descriptive Statistics of Sample by Grade Level and Time of Test

(T1 = pretest and T2 = posttest)

Variable	Kindergarten		Grade 1		Grade 2	
	T1 %(N)	T2%(N)	T1 %(N)	T2%(N)	T1 %(N)	T2%(N)
Sample	N = 66	N = 84	N = 79	N = 64	N = 101	N = 66
Sex of Individual						
Male		52.4(44)		53.1(34)		62.1(41)
Female		47.6(40)		46.9(30)		37.9(25)
Setting						
Rural	45.5(30)	39.3(33)	60.8(48)	45.3(29)	47.5(48)***	72.7(48)***
Urban	54.6(36)	60.7(51)	39.2(31)	54.7(35)	52.5(53)***	27.3(18)***

Note. Sex of individual was unavailable at T1.

***$p < .001$

The Institutional Review Board (IRB) at the University of Rhode Island (URI), guided by the IRB ethical research process, approved the original study. There were no potential or identified risks associated with participation in this study. Participation for this study was voluntary.

Measures

In response to the seminal work of Mead and Metraux (1957), which studied high school students, Chambers (1983) developed the Draw-A-Scientist Test (DAST), modeled after Goodenough's Draw-A-Man Test, to identify perceptions of scientists in elementary age children. The study concluded that drawings are more accessible to young students and students with significant language barriers, potentially making the

DAST a valid instrument to determine perception of scientists and attitudes towards science. Children are given a blank paper and asked to draw a scientist. The early work with this test was challenged because the interpretations were not standardized (Finson, 2002). Finson, Beaver, & Cramond (1995) developed a checklist to accompany the DAST. Both the DAST and the Draw-A-Scientist Test Checklist (DAST-C) have been tested and accepted as a valid tool to test perceptions of scientists (Chambers, 1983; Finson, 2002; Finson et. al., 1995; Hillman et al., 2014). This thesis analyzed DAST survey data to gauge students' perception of scientists and science self-concept.

Farland-Smith (2012) developed a DAST rubric that takes the DAST-C from a dichotomous checklist (present, not present) to a spectrum of responses (not discernible, sensationalized, traditional, outside of traditional) within three categories, appearance of scientist, location where science takes place, and activity of the scientist. Farland-Smith (2012) field tested this rubric and found it to be a reliable rubric to assess DAST survey data. The DAST rubric with some modifications was used to assess the DAST for this thesis.

Perception of scientists

This study used the DAST survey as a pre/post-assessment tool to assess the dependent variable, perceptions of scientists. The student surveys were given to the children during the school day and administered by the classroom teacher. The DAST artifacts from the pre and post-assessment were analyzed by the author of this thesis. The dependent variable, perceptions of scientists was measured using a modified version of the DAST rubric developed by Farland-Smith (2012). The researcher coded the DAST artifacts from primary grade students on three attributes: appearance, location, and activity. The coder gave a score of a 0- can't be categorized: the drawing was not detailed enough to analyze, 1- sensationalized: scientist resembles a monster or odd appearance (appearance), science takes place underground or uses unrealistic tools (location), and the work is magical or destructive (activity), 2- traditional: scientist is standard looking white male (appearance), science is done in traditional lab (location), and the scientist is studying but image does not show 'how' the work is being conducted (activity), or 3- progressive: scientist is female or of a different ethnicity (appearance), science is done outside of the traditional lab (location), the image shows how the work of the scientist is being done (activity). The attributes were analyzed separately. Figures 1 through 3 show examples of sensationalized, traditional, and progressive depictions of scientists from the data.

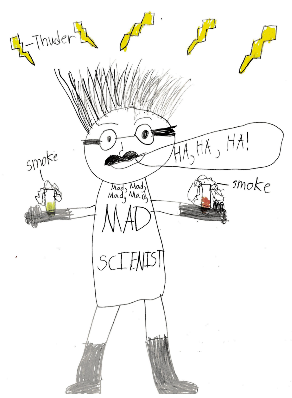

Figure 1. Depiction of a sensationalized scientist.

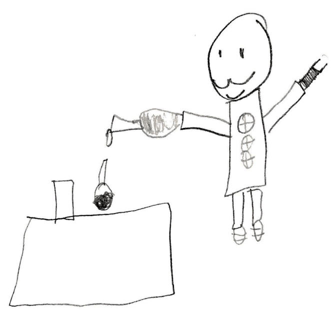

Figure 2. Depiction of a traditional scientist.

Figure 3. Depiction of a progressive scientist.

Three modifications were made to Farland-Smith's (2012) DAST rubric. First, this study changed the term "Broader than Traditional" to "Progressive" because the perceptions show change and improvement (progression) on the traditional perception of scientists. Second, the original rubric coded depictions of children or teachers as 0 whereas the current researcher added child and teacher scientist to the progressive category to encapsulate the science self-concept variable. Lastly, the current researcher elaborated on the kinds of science tools in the progressive category to include literacy tools such as science notebooks, computers or books to incorporate tools that students are expected to use in the classroom. Appendix A shows the DAST rubric with modifications made for the current thesis.

Science self-concept

The DAST survey posttest artifacts were analyzed for the dependent variable, science self-concept, and measured by two criteria: Gender of Scientist - cannot distinguish, male, female; and the Age of Scientist - cannot distinguish, child, and adult. If gender of scientists or age of scientists could not be distinguished, the data were excluded from the analysis. The criteria were compared to the respondents' gender and age. Scores were given for low self-concept - 1 - does not meet any criteria; medium self-concept - 2 - meets one of the two criteria; and high self-concept - 3 - meets both criteria (see Figure 4). See Appendix B for possible scores for both female and male students. Gender information at time 1 (T1) was unavailable therefore science self-concept scores were analyzed for drawings from time 2 (T2) only.

Figure 4. DAST illustrating a female student with high science self-concept.

GEMS-Net Intervention (Pretest/Posttest)

This thesis is concerned with the impacts of the independent variable, a teacher professional development program, Guiding Education in Math and Science Network (GEMS-Net), on primary grade students' perception of scientists and explores science self-concept of students in schools with GEMS-Net support. Data collected at time 1 (pretest) were prior to the implementation of the GEMS-Net program. GEMS-Net was implemented during the 2015-2016 school year and the duration of this study. GEMS-Net aligns the curriculum, instruction, assessment, and professional learning in science. It is expected that students engage in daily science when schools implement the GEMS-Net program. Additionally, it is expected that teachers use a constructivist approach in their science instruction. All teachers received professional development on pedagogy and science content throughout the 2015-16 school year. Professional development for all teachers was documented although fidelity to the program within the classroom was not measured in this study. It will be assumed that teachers used the program with fidelity and provided daily science instruction to students. Time 2 (posttest) data were collected at the end of the implementation year.

Other variables

Gender. Since the data for gender of students are not available at T1 in the original study, this thesis used student's self- reported gender information from the data collected at T2.

Setting. School settings are comprised of one rural school and one urban school.

Interrater reliability

Validity and reliability were of concern in the interpretation of young children's drawings. A student intern was trained to use the rubric for coding the data. The researcher and the student intern scored 171 observations (37%), to determine inter-rater reliability. Cohen's kappa was run to determine if the researcher and the student intern interpreted the data similarly. There was substantial agreement between the two raters, $k = .780$, $p < .0005$, giving the researcher confidence that the DAST rubric was being used reliably. The researcher coded the remainder of the data.

Analytic Procedures

The DAST rubric was used to quantify student drawings, SPSS 24 was employed for statistical analysis. The original study was designed to assess changes in group perceptions, not individual students' perceptions. The applicable analytic strategies are limited to interpret group changes only. To ensure independence of groups, the analysis compared time 1(T1) and time 2 (T2) within grade levels (Kindergarten to Kindergarten, Grade 1 to Grade 1, and Grade 2 to Grade 2).

Descriptive statistics included frequencies and proportions for T1 and T2 for sex of individual, school setting, perception of scientist, and science self-concept. All descriptive statistics were disaggregated by grade level (Kindergarten, Grade 1, and Grade 2). Two-way contingency tests were conducted to ensure equivalence of groups for each grade level. The two variables were GEMS-Net (T1 and T2) and setting (rural and urban).

For research question 1, cross tabulations were conducted to analyze the change in primary grade students' perception of scientists after the implementation of GEMS-Net (pre = 0 / posttest = 1). The dependent variables are treated as categorical. Binary logistic regressions controlling for setting were conducted because the Grade 2 groups were not equivalent. The variables for appearance, location, and activity were dichotomized into *progressive* and *not progressive* for the binary logistic analysis. The regressions were conducted on all three grade levels for consistency.

For research question 2, cross tabulations were employed to identify group differences in primary grade students' science self-concept by sex of individual. Overall science self-concept scores for T2 were developed by computing the gender of the scientist and the age of the scientist depicted in the DAST in relation to the sex of the individual. Science self-concept includes three levels (low, medium, high) and is represented in Appendix B. The age of scientist variable was recoded into three levels, indiscernible, adult, and child. The gender of the scientist was coded as indiscernible, male, and female. The computed science self-concept variable omitted the indiscernible level for both gender of scientist and age of scientist. Sex of individual was not available for T1 therefore science self-concept was analyzed at T2 only.

CHAPTER 4

FINDINGS

Preliminary Analysis

Descriptive statistics were conducted for demographic information by grade level. Table 1 displays the proportion and frequency of Sex of Individual (male, female) and Setting (rural, urban) for Kindergarten, Grade One and Grade Two. Sex of individual was unavailable from the pretest (T1) therefore it is not reported under T1. At T1, the urban setting comprised 48.8% (N = 120) of the observations, 51.2% (N = 126) came from the rural school setting. At T2, 48.6% (N = 104) came from the urban school whereas 51.4% (N = 110) came from the rural setting. Additional descriptive statistics for all variables were conducted to ensure correct data. There were no missing data from the 460 observations.

Equivalence of groups was determined using two-way contingency table analysis with setting (rural and urban) and GEMS-Net (Time 1 and Time 2). There was not a significant difference between the groups for the setting or time of test for Kindergarten ($\chi^2 = .577$, $p = .447$) or Grade 1 ($\chi^2 = 3.395$, $p = .07$) ensuring that the groups were similar although there was a significant difference for Grade 2 ($\chi^2 = 10.374$, $p = .001$). The unbalanced sample size (T1: N = 101 and T2: N = 66) for grade 2 was a concern although the posttest sample size of 66 is still a large enough sample to meet the assumption of cross tabulations.

Research Question 1

Perception of Scientists Differentiated by Professional Development among Kindergarten Students

A two-way contingency table analysis was conducted to evaluate whether perception of scientists differed from Time 1 (pretest), one year prior to each school participating in the GEMS-Net program, to Time 2 (posttest), one year after participating in the GEMS-Net program for Kindergarten students. The three dependent variables were appearance, location, and activity, each with four levels (indiscernible, sensationalized, traditional, progressive). The independent variable was the implementation of the GEMS-Net program. Appearance significantly differed between Pretest and Posttest, Pearson χ^2 (3, N = 150) = 24.856, $p = .000$. Table 2 shows the proportions and frequencies within the levels in all three constructs. Traditional and progressive levels were the dominant in significant changes. After the implementation of GEMS-Net, Kindergarten students' depiction of stereotypical, traditional appearance of scientists decreased by more than half, whereas the progressive appearance nearly doubled. Overall, neither the location that science takes place nor the activity of scientists varied significantly by the implementation of GEMS-Net, $p = .107$ and $p = .355$ respectively.

Table 2

Difference in Perception of Scientists from Pretest (T1) to Posttest (T2) for Kindergarten Students

Variable	T1 %(N)	T2 %(N)	χ^2	*p*
Appearance	N = 66	N = 84	24.856	.000
Indiscernible	7.6(5)	9.5(8)		
Sensationalized	13.6(9)	4.8(4)		
Traditional	36.4(24)***	8.3(7)***		
Progressive	42.4(28)***	77.4(65)***		
Location			6.903	.107
Indiscernible	21.2(14)	16.7(14)		
Sensationalized	16.7(11)*	6.0(5)*		
Traditional	18.2(12)	17.9(15)		
Progressive	43.9(29)	59.5(50)		
Activity			3.244	.355
Indiscernible	19.7(13)	13.1(11)		
Sensationalized	16.7(11)	10.7(9)		
Traditional	22.7(15)	32.1(27)		
Progressive	40.9(27)	44.0(37)		

Note. * $p < .05$ ** $p < .01$ *** $p < .001$

Next, the dependent variables, appearance of scientists, location of science, and activity of scientists, were recoded into dichotomous variables. The progressive category continued as progressive whereas indiscernible, sensationalized, or traditional were coded as not progressive. Progressive is equal to 1 if the image of a scientist is progressive and 0 otherwise. A binary logistic regression model was used to estimate the factors that influence the perception of scientists (see Table 3). The results from Step 1 indicate that Kindergarten students from urban and rural schools do not differ in perceptions of scientists. Step 2 includes the independent variable, the implementation of GEMS-Net, with pretest equal to 0 and posttest equal to 1. The implementation of GEMS-Net is a statistically significant predictor of progressive depictions in the construct of appearance of scientists for Kindergarten students at posttest with GEMS-Net explaining 17.3 % of the variance. Students in schools after the implementation of GEMS-Net were 4.80 times more likely to draw a progressive appearance of a scientist than those prior to participating in GEMS-Net classrooms. Similar to the cross tabulations analysis, location where science takes place and the activity of scientists were not significantly explained by setting or GEMS-Net involvement. The hypothesis was partially supported by the results because the perception of scientists for Kindergarten students had significantly higher odds of a more progressive depiction in the construct of appearance, although not for location or activity, after the implementation of GEMS -Net.

Table 3

Predictability of Setting and GEMS-Net on Kindergarten Students' Depiction of Progressive Perception of Scientist

Construct	Step	Variable	*B*	*SE B*	Wald χ^2	*p*	OR	95% CI	R²
Appearance	1	Urban	-.227	.343	.437	*.509*	.797	[.407, 1.561]	.004
	2	Urban	-.369	.371	.994	.319	.691	[.334, 1.429]	
		GEMS-Net	1.570	.365	18.519	.000	4.804	[2.351, 9.820]	.173
Location	1	Urban	.239	.332	.521	.470	1.270	[.663, 2.434]	.005
	2	Urban	.206	.336	.375	.540	1.229	[.636, 3.570]	
		GEMS-Net	.618	.334	3.429	.064	1.856	[.965, 3.570]	.035
Activity	1	Urban	-.013	.334	.002	.968	.987	[.512, 1.900]	.000
	2	Urban	-.022	.335	.004	*.949*	.979	[.507, 1.888]	
		GEMS-Net	.130	.334	.151	*.697*	1.139	[.592, 2.190]	.001

Note. Setting (Rural = 0, Urban = 1); GEMS-Net (Posttest = 1), the implementation of professional development.

OR = Odds ratio; CI = Confidence Interval.

Perception of Scientists Differentiated by Professional Development among Grade 1 Students

A two-way contingency table analysis (see Table 4) was conducted to evaluate whether perception of scientists was impacted from Time 1, one year prior to each school participating in the GEMS-Net program, to Time 2, one year after participating in the GEMS-Net program for Grade 1 students. The results did not support the hypothesis although appearance was trending towards significance after the implementation of GEMS-Net, Pearson χ^2 (3, N = 143) = 7.509, p = .057. However, it is interesting to note that sensationalized appearance of scientists were more prevalent for students in Grade 1 (from .18 vs. .30) post GEMS-Net. Progressive level also showed an increase (from .33 to .42) whereas traditional scientists significantly decreased (from .37 to .23) when the indiscernible category was eliminated, after participating in the GEMS-Net program.

Table 4

Differences in Perception of Scientists from Pretest (T1) to Posttest (T2) for Grade 1 Students

Variable	T1 %(N)	T2 %(N)	χ^2	*p*
Appearance	N = 79	N = 64	7.509	.057
Indiscernible	12.7(10)	4.7(3)		
Sensationalized	17.7(14)	29.7(19)		
Traditional	36.7(29)	23.4(15)		
Progressive	32.9(26)	42.2(27)		
Location			4.800	.187
Indiscernible	15.2(12)	6.3(4)		
Sensationalized	31.6(25)	31.3(20)		
Traditional	32.9(26)	29.7(19)		
Progressive	20.3(16)	32.8(21)		
Activity			1.771	.621
Indiscernible	15.2(12)	9.4(6)		
Sensationalized	32.9(26)	29.7(19)		
Traditional	29.1(23)	31.3(20)		
Progressive	22.8(18)	29.7(19)		

Note. * $p < .05$ ** $p < .01$ *** $p < .001$

Similar to kindergarten students, neither the location that science takes place nor the activity of scientists varied by GEMS-Net implementation, p = .187 and p = .621 for grade 1 students. These results were surprising and led to additional post-hoc tests. The researcher was interested in exploring gender differences in appearance of scientists in grade 1 because overall the depiction of female scientists significantly increased after the implementation of GEMS-Net and the researcher was wondering if this was evidenced in Grade 1.

Another two-way contingency table analysis was conducted to evaluate if there was a difference between girls and boys in the appearance of scientists depicted on the DAST. The independent variable was sex of individual and the dependent variable was appearance of scientist. There was a significant difference between girls and boys and the appearance of scientists after the implementation of GEMS-Net, Pearson χ^2 (3, N = 143) = 20.828, p = .000. The proportion of appearance of scientists that were indiscernible, sensationalized, traditional, and progressive for boys were .03, .41, .38, and .18, respectively. The proportion of appearance of scientists that were indiscernible, sensationalized, traditional, and progressive for girls were .07, .17, .07, and .70, respectively. Boys had a greater percentage of sensationalized scientists than in any other level, which also more than doubled the sensationalized depiction by girls. 70% of girls drew a progressive scientist at T2 compared to only 18% of boys. This might be explained by the trend that girls drew more female scientists after the implementation of GEMS-Net: this trend is analyzed more closely in research question 2.

Next, the dependent variables, appearance, location, and activity were recoded into dichotomous variables, progressive (1) and not progressive (0). The progressive category continued as progressive whereas indiscernible, sensationalized, or traditional were coded as not progressive. A binary logistic regression model was completed to determine the relationship between the variables (urban setting and implementation of GEMS-Net) and progressive perceptions of scientists (see Table 5). The results from Step 1 indicate that Grade 1 students situated in the urban school setting differ in the progressive depiction of scientists in all three constructs: appearance, location, and activity. The final model includes the implementation of GEMS-Net (posttest = 1). The implementation of GEMS-Net is a not a statistically significant predictor of progressive depictions of scientists for Grade 1 students. The urban setting explains 6.4% of the variance of progressive appearance and 11.7% of the variance of progressive location and activity. Grade 1 students from the urban school were 2.41 times more likely to draw a progressive appearance of a scientist, and 3.66 times more likely to draw progressive location and activity of scientists than the students in the rural setting after controlling for GEMS-Net.

Table 5

Predictability of Setting and GEMS-Net on Grade 1 Students' Depiction of Progressive Perception of Scientist

Construct	Step	Variable	*B*	*SE B*	Wald χ^2	*p*	OR	95% CI	R^2
Appearance	1	Urban	.920	.355	6.713	.010	2.510	[1.251, 5.034]	.064
	2	Urban	.882	.359	6.038	.014	2.415	[1.195, 4.879]	
		GEMS-Net	.274	.359	.584	.445	1.316	[.651, 2.660]	.069
Location	1	Urban	1.361	.4121	10.926	.001	3.900	[1.740, 8.740]	.117
	2	Urban	1.299	.416	9.765	.002	3.665	[1.623, 8.277]	
		GEMS-Net	.497	.403	1.522	.217	1.644	[.746, 3.622]	.131
Activity	1	Urban	1.361	.412	10.926	.001	3.90	[1.740, 8.740]	.117
	2	Urban	1.336	.415	10.341	.001	3.804	[1.685, 5.588]	
		GEMS-Net	.174	.402	.186	.666	1.189	[.666, 1.189]	.119

Note. Setting (Rural = 0, Urban = 1); GEMS-Net (Posttest = 1), the implementation of professional development.

OR = Odds ratio; CI = Confidence Interval.

Perception of Scientists Differentiated by Professional Development among Grade 2 Students

A two-way contingency table analysis was conducted to evaluate whether perception of scientists differed from Time 1, one year prior to each school participating in the GEMS-Net program, to Time 2, one year after participating in the GEMS-Net program for Grade 2 students. The hypothesis was supported in all three constructs in Grade 2. Appearance varied significantly after the implementation of the GEMS-Net program, Pearson χ^2 (3, N = 167) = 19.022, p = .000. Table 6 shows proportions, frequencies, and Chi squared results for Grade 2. When teachers are supported by the GEMS-Net science program Grade 2 students' perception of scientists change. The progressive appearance of scientists doubled and the sensationalized appearance decreased from 30% to less than 10%.

Location was also significantly differed after the implementation of GEMS-Net, Pearson χ^2 (3, N = 167) = 26.993, p = .000 with sensationalized and progressive levels showing greater frequency. More than three times as many Grade 2 students depicted science being done outside of the traditional lab setting after participating in the GEMS-Net program for one year as compared to one year prior.

The activity of the scientists was found to be significantly different between T1 and T2 on three levels, sensationalized, traditional, and progressive, Pearson χ^2 (3, N = 167) = 52.393, p = .000. Prior to GEMS-Net, 53% of Grade 2 students perceived science as magical or dangerous. After one year of support from GEMS-Net, only 2% of the DAST showed depictions of magical or dangerous science whereas 44% of Grade 2 students drew scientists engaging in true scientific practices. Table 6 presents the data for the cross tabulation analysis on all three constructs.

Table 6

Differences in Perception of Scientists from Pretest (T1) to Posttest (T2) for Grade 2 Students

Variable	T1 %(N)	T2 %(N)	χ^2	*p*
Appearance	N = 101	N = 66	19.022	.000
Indiscernible	3.0(3)	3.0(2)		
Sensationalized	30.7(31)	9.1(6)		
Traditional	34.7(35)	24.2(16)		
Progressive	31.7(32)	63.6(42)		
Location			26.933	.000
Indiscernible	10.9(11)	6.1(4)		
Sensationalized	45.5(46)	21.2(14)		
Traditional	30.7(31)	24.2(16)		
Progressive	12.9(13)	48.5(32)		
Activity			52.393	.000
Indiscernible	5.9(6)	4.5(3)		
Sensationalized	52.5(53)	1.5(1)		
Traditional	28.7(29)	50.0(33)		
Progressive	12.9(13)	43.9(29)		

A logistic regression was performed to ascertain the effects of urban setting and the implementation of GEMS-Net on the likelihood of progressive perception of scientists (see Table 7). The results from model 1, which included urban setting as a covariate, are not statistically significant. Model 2, when GEMS-Net was added, was statistically significant, Wald $\chi^2 = 3.839$, $p = .050$. The variance changed dramatically from .5% to 15.6%. After participating in GEMS-Net, students have 4.68 higher odds of drawing a progressive appearance of a scientist than the student participants prior to GEMS-Net. Urban setting was not a significant predictor of progressive locations of science (Wald χ^2 = 1.926, *p* = .165). GEMS-Net explains 22.1% of the variance for the location construct. Students in GEMS-Net are 7.59 times more likely to depict science happening outside of the traditional lab setting. Again, the activity of the scientist was not explained by setting. The implementation of GEMS-Net was a significant predictor of change in progressive activity of scientists (Wald χ^2 = .266, *p* = .606). 17.1% of the variance of how science is done was explained by the implementation of the GEMS-Net science program. After the implementation of GEMS-Net, Grade 2 students had 5.61 higher odds of drawing scientists engaged in true scientific practices as compared to students in the pretest groups.

Table 7

Predictability of Setting and GEMS-Net on Grade 2 Students' Depiction of Progressive Perception of Scientist

Construct	Step	Variable	*B*	*SE B*	Wald χ^2	*p*	OR	95% CI	R²
Appearance	1	Urban	.252	.315	.639	.424	1.286	[.694, 1.286]	.005
	2	Urban	.703	.359	3.839	.050	2.019	[1.000, 4.077]	
		GEMS-Net	1.543	.303	18.212	.000	4.679	[2.304, 9.506]	.156
Location	1	Urban	-.016	.353	.002	.963	.984	[.492, 1.965]	.000
	2	Urban	.576	.415	1.926	.165	1.779	[.789, 4.013]	
		GEMS-Net	2.028	.416	23.744	.000	7.597	[3.361, 17.175]	.221
Activity	1	Urban	-.244	.365	.447	.504	.783	[.383, 1.603]	.004
	2	Urban	.210	.407	.266	.606	1.234	[.555, 2.740]	
		GEMS-Net	1.725	.405	18.187	.000	5.614	[2.541, 12.406]	.171

Note. Setting (Rural = 0, Urban = 1); GEMS-Net (Posttest = 1), the implementation of professional development.

OR = Odds ratio; CI = Confidence Interval.

Research Question 2

Science Self-Concept differentiated by Professional Development at T2

Frequencies and proportions were found for T2 science self-concept scores (N = 214) after the implementation of GEMS-Net. The indiscernible items were omitted (N = 48, 22%) making the sample for this variable 166 observations. Science self-concept was measured by comparing the students' gender and age to the gender and age of the scientist drawn. The science self-concept score was then coded into three levels (low, medium, and high). Table 8 shows the frequencies and proportions of low, medium, and high science self-concept scores. More than half of the primary grade students had a medium to high science self-concept score with over 40% showing high science self-concept. Although this was not compared to the T1 data, when teachers are supported by GEMS-Net, a majority of students' show medium to high science self-concept.

A two-way contingency test was conducted to discern the differences between girls and boys in science self-concept scores. There was a statistically significant difference specifically in the medium and high categories, Pearson χ^2 (2, N = 166) = 12.066, $p = .002$. The data show that 69.7% of girls had high science self-concept compared to only 44.4 % of boys whereas 47.8% of boys show a medium science self-concept, only 22.4 % of girls received medium science self-concept scores. After the implementation of GEMS-Net, girls identify themselves with scientists (see Table 8).

Table 8

Science Self-Concept Scores at Posttest Differentiated by Sex of Individual (N = 166)

Science Self-Concept Scores	Frequency	Percent	Boys n (%) n = 90	Girls n (%) n = 76	Pearson χ^2
Low	13	6.1	7(7.8)	6(7.9)	12.066**
Medium	60	28.0	43(47.8)**	17(22.4)**	
High	93	43.5	40(44.4)**	53(69.7)**	

Note. Science self-concept scores were found at T2 only. 22.4% of data was omitted due to indiscernible data.

**$p = .01$

The science self-concept scores were limited because the sex of the individual was unavailable for pretest data; the researcher could not compare differences in science self-concept from pretest to posttest. In order to clarify, post-hoc tests were conducted to analyze science self-concept further using both pretest and posttest data. Another two-way contingency table was employed to evaluate the impacts of GEMS-Net on the gender of the scientists drawn. Female scientists significantly increased from 67 (27.2%) to 92 (43.0%), Pearson χ^2 (2, N = 460) = 31.912, p = .000, after the implementation of GEMS-Net.

Finally, a two-way contingency table was conducted to evaluate the percentage of students who drew a scientist that aligned to their own gender after the implementation of GEMS-Net. The data show that most students drew scientists that align with their own gender, 84.2% of girls drew female scientists and 83.2% of boys drew male scientists.

CHAPTER 5

DISCUSSION

Perceptions of Scientists

Gottfredson (1981) theorized that occupational images and self-concept affect career aspirations. These perceptions of occupations and gender identity develop at a young age. Most importantly, once a career is eliminated it is rarely reconsidered.

Appearance. This study provides evidence that teacher professional development can positively affect the occupational image of scientists. Kindergarten and Grade 2 students showed statistically significant progressive perceptions of the appearance of scientists after the implementation of GEMS-Net. This result is congruent with Denessen, Vos, Hasselman, and Louws (2015)'s study outcome that teachers' attitudes towards science influence student outcomes.

Grade 1 students were trending towards significance, although, Grade 1 students from the urban setting were more likely to draw a progressive appearance of scientists than those in the rural setting. Grade one teachers in the urban setting may have implemented the program with more fidelity than the teachers in the rural school setting. Teacher attitudes towards pedagogical changes and professional development have been correlated to stages of teaching. Teachers who are receptive to new teaching strategies showed positive attitudes towards professional development and professional growth while teachers who have reached a plateau in their teaching or are frustrated with the profession tend to hold negative attitudes towards professional development and are less motivated to change (Maskit, 2011). In Maskit's 2011 study, on-going professional development that includes classroom support over time showed a decrease in negative attitudes and barriers to professional development (Maskit, 2011). Future research could investigate whether Grade 1 students' perceptions of scientists become more progressive in both settings after the schools have participated in GEMS-Net for two or three years.

The current study adds to the literature developing the argument that children as young as five years old have traditional and sensationalized perceptions of appearance of scientists that can be addressed through a positive school science experience when teachers are supported with materials and effective professional development.

Location and activity. Kindergarten and Grade 1 students did not show a significant difference in where or how science is done. This might be explained by developmental stages and limited sophistication in drawings at this age. Young children use illustration to represent their view of the world, which is appropriately egocentric (Kellogg, 1969). However, this study only looked at the first year of implementation of GEMS-Net and might show different outcomes after two or three years of support. Future studies might revisit these schools and compare the change over time for Kindergarten and Grade 1 students understanding of where and how science is done in regards to the greater science community.

Grade 2 students' DAST did depict science being done outside of the traditional laboratory setting and showed scientists actively using appropriate tools to study multiple science concepts and fields. The classic view of scientists working alone in a laboratory differed when teachers were supported in science instruction and students had access to a hands-on, constructivist approach to science that aligns with the vision of the Next Generation Science Standards (NRC, 2011). Students in this study were nearly 8 times more likely to draw science happening outside of the traditional lab setting and more than 5 times as likely to portray true scientific practices. Students might keep STEM occupations in their career choices when they understand the variety of settings and true work that scientists pursue.

The method used to develop the DAST rubric allowed researchers to gain a more detailed picture of students' perceptions of scientists by not only including the appearance of the scientist but also analyzing the details in the setting (location) and the activity of the scientists (Farland-Smith, 2012).

Science Self-Concept

The second research question in this study adds to the limited literature on gender differences in science self-concept (Leibham, Alexander, & Johnson, 2013). A majority of students in this study identified with scientists allowing them to keep science as an option in future career choices. After teachers received support in science, 84% of girls drew female scientists. Women are still grossly underrepresented in science, technology, engineering, and math (STEM) fields (Beede et al., 2011). The results from the current study can help the professional development community address the underrepresentation of women in STEM fields. Both boys and girls drew scientists that aligned with their own gender giving evidence that all students can benefit from teacher professional development programs that support science education. Teacher professional development may be an essential component to support female students' interests in STEM related fields.

Limitations

Teachers and students were unidentified in the dataset limiting access to confounding variables that may affect change in students' perceptions of scientists and science self-concept. In future research, giving teachers and students identification numbers would allow the researcher to gather demographic information that might help explain results in greater depth. For example, collecting information on the number of years teaching and teacher attitudes towards science would be interesting to correlate to students' perception of scientists. The urban school setting was a charter school with a maritime focus, which is science related. The teachers in the school may hold more positive attitudes towards science therefore may have implemented the GEMS-Net program with greater fidelity than the teachers from the rural school setting.

Additionally, sex of individual students was not available for pretest (T1) data limiting the analysis of science self-concept results. Change over time in science self-concept was not analyzed although information on differences in the gender of the scientists from pretest to posttest showed positive and significant impacts.

The developmental stages of Kindergarten and Grade 1 students' drawings may have affected the results for the location where science takes place and how science is done. Additionally, ethnicity of scientists was not accessible because many drawings were pencil only. In future research, supplying classrooms with multi-cultural skin-toned crayons and more specific protocol that specifies that students use color pencils or crayons could elicit more detailed drawings.

Lastly, the two coders were not blind to which DAST came from the pretest and which DAST came from the posttest. This has the potential to affect coder bias.

APPENDICES

APPENDIX A

Modified DAST Rubric

Attribute	Can't be Categorized	Sensationalized	Traditional	*Progressive
APPEARANCE	Examples -No Scientist -Historical Figure *~~ reflects teacher or student~~ Difficult to discern	Male or female who resembles a monster, or who has clearly geeky appearance (example: crazy hair, odd appearance, cape).	Standard-looking white male or standard-looking scientist unable to determine gender. This scientist clearly lacks any references that are bizarre (Example: humpback).	Female, person of different ethnicity, child, or two or more scientists.
Score	0	1	2	3
LOCATION	Difficult to discern	Resembles a basement, cave, or setting of secrecy and/or horror. Often elaborate, with equipment not normally found in a laboratory (example:bubbling beakers).	Traditional lab setting- a table with equipment in a normal-looking room (Example: beakers without bubbles)	Anywhere other than a traditional lab setting.
Score	0	1	2	3
ACTIVITY (with support or *without support from caption)	Difficult to discern	The scientist's work is either magical or destructive, or embellishes the drawing with a storyline that is about spying, stealing, killing,or scaring. Often science done unrealistically under hazardous conditions (example: destructive, toxic potions, or explosives).	"The scientist is studying or is trying to…" but caption *or drawing does not show HOW the scientist is studying or researching. Student sees the scientist involved in work miraculous in nature (naive on the part of the student), not destructive.	"The scientist is studying…"and the caption or drawing shows HOW the scientist is doing this. Indicates that the student is portraying the type of work that a scientist might actually do with the tools needed. *tools may include literacy component for example science notebook or books
Score	0	1	2	3

*modified from Farland-Smith DAST rubric (2012)

APPENDIX B

Combination of Gender and Age of Scientists to Create Science Self-concept Scores

Student Gender	Gender of Scientist	Age of Scientist	Science Self-Concept Score
Female	Male	Adult	0 - low
	Male	Child	1 - medium
	Female	Adult	1 - medium
	Female	Child	2 - high
Male	Female	Adult	0 - low
	Female	Child	1 - medium
	Male	Adult	1 - medium
	Male	Child	2 - high

Note. Analyzed at T2 only

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