AN EXPLORATION OF THE USE OF SCIENCE SPECIALISTS AND ELEMENTARY STUDENTS' SCIENCE ACHIEVEMENT

Wesley Roach
Liberty University
waroach@liberty.edu

Jillian L. Wendt
University of the District of Columbia
jillian.wendt@udc.edu

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ABSTRACT

The purpose of this causal-comparative study was to examine the effect of using science specialists in elementary schools on science achievement scores. The sample population consisted of 282 fifth grade students enrolled in Georgia public schools. The data for this study was collected from four public elementary schools' end-of-year state assessments and analyzed as archival data. An analysis of covariance (ANCOVA) was used to determine if there was a difference between science achievement scores in elementary schools that use science specialists compared to those that do not. Results indicate that no statistically significant difference exists between the science achievement scores of students enrolled in schools that use science specialists for science instruction compared to those that do not. Implications of the findings are discussed relating to education practice, administration, and needs for future study.

KEYWORDS

science specialist, generalist, instruction, elementary science, science achievement

Within the field of education, it is widely recognized that science literacy is imperative to preparing a citizenry capable of ensuring globally competitive progress as well as scientifically based decision making. Over 60 years ago, President Dwight Eisenhower addressed the U.S. Congress about the importance of science education stating, “if we are to maintain our position of leadership, we must see to it that today’s young people are prepared to contribute the maximum to our future progress” (Eisenhower, 1958, p. 103). Over 52 years later, President Barak Obama (2009) echoed similar sentiments in his address to the National Academy of Sciences when he stressed that countries that provide the strongest education for their students will have a competitive advantage over other countries. It is well known that the wellbeing of the country is dependent on citizens being scientifically literate (Gibbons, 2003; Huderson & Huderson, 2019; National Research Council [NRC], 2013a, 2013b), and that literacy begins with strong elementary science education (Barak & Dori, 2011; Ravanis, 2017).

Unfortunately, the need for qualified people to enter career fields related to science far exceeds the current rate at which people are entering such career fields (Bureau of Labor Statistics, 2019; President’s Council of Advisors on Science and Technology [PCAST], 2012). Furthermore, reports indicate that U.S. students often lag in science performance behind their counterparts from other countries around the world (Kena et al., 2016; NRC, 2013b). The most recent available National Assessment of Educational Progress ([NAEP], 2021) report indicated that fourth grade students scored lower in science in 2019 as compared to 2015, indicating that students are still struggling with science achievement. To address the need for more qualified people to enter career fields related to science and to bolster the science achievement of U.S. students, there must be effective science instruction in elementary schools (Kier & Lee, 2017; Nelson & Landel, 2007; NRC, 2013a).

It has been demonstrated that students are more likely to develop stronger interests in science and to pursue more advanced science courses when they have been exposed to engaging science instruction in elementary school (Campbell & Chittleborough, 2014; Hanuscin, 2007; McGrew, 2012; McNeill & Pimentel, 2010; Smith et al., 2016). Furthermore, students who are given the opportunity to engage with authentic science practices are more likely to develop proficient scientific literacy (Diaconu et al., 2012; Jones et al., 2012; Qarareh, 2016). However, in many elementary schools, the time allotted for science instruction has historically been shortened to allow for an emphasis on subjects such as reading and mathematics (Banilower et al., 2013; Blank, 2013; Bybee, 2013; Milner et al., 2012; NRC, 2015; Olson et al., 2015). Studies indicate that many elementary teachers express a preference for teaching subjects other than science (Kirst & Flood, 2017; Scott, 2016; Wilson & Kittleson, 2012) and others may not feel that they are adequately prepared to teach science (Gillies & Nichols, 2015; Wendt & Rockinson-Szapkiw, 2018; Wilson & Kittleson, 2012;). Baldi et al. (2015) reported that 92% of the elementary teachers in their study were charged with teaching all subjects in a self-contained setting, meaning that they are not able to specialize in any one subject. This can be problematic when teachers are not provided sufficient training and supports to enable scientific expertise and development of content knowledge (Kier & Lee, 2017; Schwartz & Gess-Newsome, 2008).

Conceptual Framework and Background

The teaching of science is distinguished from other subjects because of its unique nature. There are research-based strategies that may be employed to teach students to read (Walpole & McKenna, 2017). Algorithms may be learned, and proven approaches to problem solving may be applied to learn mathematics (Krawec & Montague, 2014). Themes from the human experience may be reinforced in social studies to help prepare students to be productive citizens in our democratic society (Pryor et al., 2016). But effective science teaching is complex in the sense that science instruction that is oriented only around the memorization of subject content does not lead to the kind of deep understanding of science that students need to acquire to become scientifically literate citizens (Aydeniz et al., 2012; Steinberg et al., 2015). Teacher content knowledge and pedagogical prowess surrounding the effective implementation of science has been cited as a key indicator for the measurement of progress toward enhancing participation and success in K-12 science education (NRC, 2013a).

A pivotal publication, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Idea* (NRC, 2012) gave rise to the *Next Generation Science Standards: For States, By States* (NGSS), which in turn has helped to shape current reforms in K-12 science education (NRC, 2013b). The NGSS defines what should be learned by the time a student graduates from high school and, importantly, the fact that such learning must begin at a young age (NRC, 2013b). Thus, it is essential to consider what model of science instruction best meets the demands for effective and rigorous elementary science instruction that engages students and aligns with best practices, including standards, in science. Understanding the frameworks and models that support current science education efforts is important as it brings to light the need to ensure depth and breadth of knowledge of those who are teaching science in the field—thus, ensuring depth and breadth of students' science learning (Next Generation Science Standards [NGSS], 2013).

Effective science learning must engage students in ways that go beyond the mere memorization of science facts by emphasizing the practices and crosscutting concepts of science. One of the challenges for elementary teachers is that many of them have neither experienced nor been trained in these kinds of instructional practices (Olson et al., 2015; Steinberg et al., 2015). Furthermore, most elementary teachers have been trained to be generalists. That is, they are expected to teach all subjects to their students (Dejarnette, 2016; Schwartz & Gess-Newsome, 2008) and, thus, may not hold content expertise in all areas or perceive that they are knowledgeable in all areas. As the elementary classroom has been cited as foundational to the development of students' understandings of science as a practice (Kier & Lee, 2017), there is a continued need to explore methods for enhancing science instruction in the classroom and for providing such science expertise. One potential method for providing science instruction with increased expertise is the use of science specialists—individuals who have received degrees or enhanced training in science and who are tasked with teaching only science (Schwartz & Gess-Newsome, 2008).

The Use of Elementary Science Specialists

The literature supports that there are several barriers to the goal of effective science instruction and learning in elementary schools. Many elementary teachers express a preference for non-science subjects (Kirst & Flood, 2017; Marco-Bujosa & Levy, 2016; Scott, 2016) and often express a lack of confidence in the area of science content (Gillies & Nichols, 2015; Wendt & Rockinson-Szapkiw, 2018; Wilson & Kittleson, 2012). The amount of instructional time for science in elementary schools is often abbreviated to allow more time for teaching reading and mathematics (Banilower et al., 2013; Blank, 2013; Bybee, 2013; Milner et al., 2012; NRC, 2015; Olson et al., 2015). These factors, and others, may have contributed to the current state of science achievement for U.S. students, who score lower on some science assessments than many of their counterparts around the world (Kena et al., 2016). The National Academies of Sciences, Engineering, and Medicine (2016) highlighted the importance of scientific knowledge and scientific literacy for the purpose of preserving a democratic way of life and a vibrant economy.

In response to the need for more effective and rigorous elementary science instruction some elementary schools have turned to the use of elementary science specialists (Abell, 1990; Hounshell, 1987; Poland et al., 2017; Schwartz & Gess-Newsome, 2008; Williams, 1990). While the role and training of elementary science specialists varies from state to state or even from school to school (Brobst et al., 2017), they are typically charged with teaching only science and tend to have some additional training in the areas of science content or science instruction (Baldi et al., 2015; NRC, 2014; Olson et al., 2015), although the amount and type of training is not consistent from school-to-school. Claims have been made that elementary science specialists hold several advantages over elementary teachers who are generalists when it comes to effective science instruction, including a greater likelihood to have had more advanced training or degrees in science; a higher level of confidence in the field of science; a greater familiarity with science curriculum; and more time to prepare science lessons and to know students' needs in science (Brobst et al., 2017). Despite the advantages claimed for using elementary science specialists, only 26% of elementary students in the U.S. receive instruction from science specialists (Banilower et al., 2013).

While the idea of using science specialists to support the elementary generalist is not new and has been relatively widely employed, little research has explored the impact of science specialists on students (Levy et al., 2016). Thus, it is not currently known whether the use of science specialists has any impact on student learning and, importantly, student achievement in science. Studies that have examined the use of science specialists tend to have explored science specialists' development of identity (Kier & Lee, 2017), elementary teachers' perspectives surrounding the use of science specialists (Poland et al., 2017), and the impact of school supports on the teaching of science (Marco-Bujosa & Levy, 2016).

Of the few studies that have examined the effectiveness of using science specialists in elementary schools, the results have yielded conflicting conclusions (Levy et al., 2016; Marco-Bujosa & Levy, 2016;). For instance, when examining the impact of school supports on science teaching among schools utilizing science specialists, results indicated that myriad challenges exist in providing effective science instruction (Marco-Bujosa & Levy, 2016). More specifically, the science specialist model was not found to be sufficient in overcoming such school-based challenges. School conditions, such as administrative support, appeared to have a greater influence on science teaching than the use of science specialists alone, thus calling into question whether the use of science specialists was indeed beneficial.

Another study examined students' achievement scores on a state-mandated standardized test across schools that utilized science specialists compared to those who did not utilize science specialists over the course of four years (Levy et al., 2016). The results indicated that no statistically significant difference existed among students' scores when receiving science instruction from a science specialist compared to a generalist. However, when comparing mean scores, a small (although non-significant) difference was noted, with students who received instruction from science specialists scoring slightly higher than those who received instruction from a generalist.

As such, a dearth exists in studies that explore the potential impact of science specialists on student science outcomes. Researchers have continued to call for research that explores the use of science specialists in the elementary classroom (Brobst et al., 2017; Kier & Lee, 2017; Poland et al., 2017), especially in relation to student outcomes (Marco-Bujosa & Levy, 2016). Thus, the purpose of this causal-comparative study was to consider the following research question: Is there a statistically significant difference in the science achievement of fifth graders as measured by the Georgia Milestones Assessment System (GMAS) between schools where science specialists deliver science instruction and schools where generalists deliver science instruction?

Methodology

For this study a causal-comparative research design was used (Gall et al., 2007). The researchers collected archived science achievement data measured by the Georgia Milestones Assessment System (GMAS) for two consecutive years for students from two schools where science specialists (n = 2) were used to deliver science instruction and from two schools where generalists (n = 8) were used to deliver science instruction. The archived science achievement data included the students' scores from their fourth-grade assessment and from their fifth-grade assessment. The students' fourth-grade assessment scores served as a pretest for the purpose of controlling for students' prior science achievement.

The independent variable for this study was the type of teacher who delivered science instruction to the students. The nominal categories of the independent variable were science specialists (teachers who taught only science) and generalists (teachers who taught all subjects). Aligning with the research literature (Abell, 1990; Schwartz & Gess-Newsome, 2008) science specialists were defined as teachers with training in science content and pedagogy and who were tasked with teaching only science (Baldi et al., 2015; NRC, 2014; Olson et al., 2015). Since the type and amount of training that science specialists receive has not been consistent within the field or body of literature, the researchers confirmed that the science specialists utilized at the schools selected for this study had received science-specific professional training, including job-embedded training, and STEM professional development (e.g., STEM conferences and workshops).

The dependent variable for this study was students' science achievement – defined as the understanding of basic science concepts and the comprehension and application of scientific processes (Carrier, Thomson, Tugurian, & Stevenson, 2014). The dependent variable was measured by the GMAS. The GMAS measures students' proficiency in science concepts as well as their understanding of science practices as prescribed by the Georgia Standards of Excellence (GSE) curriculum guide (Georgia Department of Education [GaDOE], 2016a, 2017b). The use of a standardized assessment aligns with previous research that has examined the impact of science specialists on students' achievement outcomes (Levy et al., 2016) and, thus, was deemed appropriate for the current study.

Participants

Convenience sampling was used to select 282 fifth grade students' archival data for this study. Sample schools were selected by considering whether the schools used or did not use science specialists and by matching schools for similar demographics (gender ratio, race/ethnicity ratio, and socioeconomic status). After considering the available schools, four schools were selected—two that used science specialists and two that did not. In total, among the sample schools selected, there were 121 students from two schools where science specialists delivered science instruction and 161 students from two schools where generalists delivered science instruction. Thus, 121 of the students participating in this study received their science instruction during their fourth-grade year from a science specialist while 161 students participating in this study received science instruction from a generalist (see Table 1). None of the participants included in the sample had Individualized Education Plans (IEPs) and all of them had been in the same school for both their fourth- and fifth-grade years. The student population in the science specialist schools was comprised of 94% White students, 5% Hispanic students, and less than 1% multiracial students. The student population in the generalist schools was comprised of less than 1% Black students, 91% White students, 7% Hispanic students, less than 1% Asian students, and 1% multiracial students (see Table 1). The student population in the science specialist schools was comprised of 49% male students and 51% female students. The student population in the generalist schools was comprised of 48% male students and 52% female students (see Table 2). The student population in the science specialist schools was comprised of 67% economically disadvantaged students. The student population in the generalist schools was comprised of 56% economically disadvantaged students (see Table 3).

Table 1
Student Race/Ethnicity Summary for Study Subjects from Participating Schools

	Schools Where Specialists Teach Science			**Schools Where Generalists Teach Science**		
Demographic Description	**School A**	**School B**	**Total**	**School C**	**School D**	**Total**
Black	0	0	0	1	0	1
White	49	65	114	81	65	146
Hispanic	2	4	6	5	6	11
Asian	0	0	0	0	1	1
Multi-Racial	1	0	1	1	1	2
Other	0	0	0	0	0	0
Total	52	69	121	88	73	161

Table 2
Student Gender Summary for Study Subjects from Participating Schools

	Schools Where Specialists Teach Science			**Schools Where Generalists Teach Science**		
Gender Description	**School A**	**School B**	**Total**	**School C**	**School D**	**Total**
Male	23	36	59	47	30	77
Female	29	33	62	41	43	84
Total	52	69	121	88	73	161

Setting

The schools selected for this study were four accredited public elementary schools in rural northeast Georgia. The schools were selected because two were identified as having used

Table 3
Student Economic Status Summary for Study Subjects from Participating Schools

	Schools Where Specialists Teach Science			Schools Where Generalists Teach Science		
Economically Disadvantaged	School A	School B	Total	School C	School D	Total
Yes	37	44	81	45	45	90
No	15	25	40	43	28	71
Total	52	69	121	88	73	161

science specialists to deliver science instruction to students and two were identified as having not used science specialists to deliver science instruction based on surveys sent to school district principals. Additionally, as noted previously, the schools were similar in their racial and socioeconomic demographics. All four schools administered the GMAS each Spring semester as a means of assessing students' achievement levels based on the standards prescribed by the Georgia Standards of Excellence (GSE), which was the curriculum used in all public schools in Georgia at the time of the study.

Instrumentation

As noted, this study used the GMAS to measure science achievement. The GMAS was developed by the Georgia Department of Education (GaDOE) to measure students' learning and progress in each academic subject for grades three through eight (GaDOE, 2017a). The GMAS science assessment for fifth grade is comprised of 75 multiple choice items, 45 of which are criterion referenced, 20 of which are referenced to national norms, and 10 of which are field test items that do not count toward the students' scores. The test is taken in two sessions for which students are given 70 minutes per session. Students receive both a scaled score as well as an achievement level designation to indicate their level of science achievement. The three science domains represented on the test and their respective weights are Earth science at 30%, physical science at 30%, and life science at 40%. According to the GaDOE (2016b, 2017c) the GMAS science tests used for this study have median Cronbach's alpha reliability coefficients of 0.90 for the fifth-grade test, which was used for the dependent variable, and 0.91 for the fourth-grade test, which was used for the pretest for the purpose of a covariate.

Procedures

Principals at prospective schools were asked to complete a survey that described their schools' science instruction, including whether a science specialist or a generalist taught science. After institutional research board (IRB) approval was granted, schools were selected for the study. Two schools were selected where science specialists were used to teach science and two schools were selected where generalists were used to teach science. Since this study relied only on archival data that was accessible by request from the GaDOE it was not necessary to secure consent from the schools included in the study. However, a letter was sent informing principals that their schools' archived data related to students' performance on the GMAS science test would be used.

A request was made to the GaDOE for the archived GMAS scores for the students in the selected schools. The 2015-2016 school year fourth grade science scores and the 2016-2017 school year fifth grade science scores were requested. The GaDOE sent all requested data with all student identifiers removed and replaced with non-identifying student numbers. In addition to the science scores, the students' status as having diagnosed disabilities was also requested so that those students' scores could be removed from the data before any analysis of the data was conducted. Other requested data included students' gender, race, and free and reduced lunch qualification status. Any students who did not have test scores for both the 2015-2016 school year and the 2016-2017 school year were removed before any analysis of the data was conducted.

Analysis and Results

To test for statistical significance in the difference between the posttest mean scores for students who received instruction from a science specialist and students who did not receive instruction from a science specialist while controlling for prior science achievement, an ANCOVA was conducted. To control for threats to validity, two groups were used (Warner, 2013; one group of students who did not receive instruction from a science specialist and one group of students who did receive instruction from a science specialist, although variables were not manipulated given the ex post facto nature of the study. Prior to proceeding with the ANCOVA, assumption testing was conducted. The possibility of outliers was examined by visual inspection of boxplots and standardized values, and no outliers were identified. Kolmogorov-Smirnov was used to determine the tenability of the assumption of normality of the covariate scores and the dependent variable scores and was found tenable ($p = .200$), suggesting that there was an approximately normal distribution of each variable (Warner, 2013). A scatterplot was visually examined to verify the assumption of linearity between the covariate scores and the dependent variable scores and was deemed tenable. Levene's Test for Homogeneity of Variance was used to verify that there was similar variance of the dependent variable between each group and was deemed tenable ($F(1, 280) = 1.30$, $p = .256$).

The results of the ANCOVA revealed that there was no statistically significant difference between the posttest mean scores for the two groups while controlling for prior science achievement, $F(1, 279) = 0.56$, $p = .455$. Descriptive statistics are shown in Table 4.

Table 4
Descriptive Statistics for GMAS Science Scaled Scores (N=282)

GMAS Science Scaled Score	*n*	*M*	*SD*
2015-2016 (Pretest)			
Overall sample	282	524.54	40.61
Science specialist	121	512.99	39.04
Generalist	161	533.22	39.70
2016-2017 (Posttest)			
Overall sample	282	541.03	55.51
Science specialist	121	530.12	51.70
Generalist	161	549.24	57.00

While controlling for the effects of pretest scores which represented prior learning, the marginal science achievement score means for the group receiving instruction from science specialists was M = 539.69 (SE = 2.68, n = 161) while the science achievement score mean for the group not receiving instruction from science specialists was M = 542.81 (SE = 3.11, n = 121; see Table 5). These results indicate that students receiving science instruction from an elementary science specialist scored lower on the GMAS than students receiving science instruction from an elementary generalist. However, the difference in mean scores was small and statistically non-significant.

Table 5
Marginal Means for Posttest Scores by Type of Teacher Delivering Science Instruction

Specialist	Marginal Posttest Means	*SE*	*n*
Science Specialist	539.69	2.68	161
Generalist	542.81	3.11	121

Discussion

The results of the ANCOVA indicated that there was no statistically significant difference in the science achievement for students taught by science specialists and students not taught by science specialists in this study. This aligns with previous research that demonstrated no statistically significant difference in students' science standardized test scores when receiving instruction from science specialists as compared to generalists (Levy et al., 2016). In the previous study, Levy et al. (2016) asserted that there are several factors that impact science achievement, including the overall value placed on science in the school; the principal's support for the science program in the school; the resources made available for the science program; the quality of teachers in the school; the quality of instruction in the school; and the quantity of time allocated for science instruction in the school. Furthermore, Levy et al. (2016) and Marco-Bujosa and Levy (2016) supported that many factors may influence science achievement.

In the current study, it was hypothesized that the use of science specialists, given their exposure to job-embedded and STEM-related professional development, would provide an enhanced quality of science instruction to students, translating to higher student science achievement. Further, the current study also hypothesized that the inclusion of science specialists in the selected schools would serve as a demonstration of principals' support for science programs in the school. While these hypotheses may in fact be true, they did not yield a statistically significant difference in students' science achievement scores. Thus, the current study supports that the use of science specialists alone may not impact students' science achievement and that other factors, including the quality of instruction, specific instructional practices, and level and quality of principal support may indeed play a significant role. It is important to continue exploration to tease out individual factors that influence students' science outcomes and what specific role science specialists play in impacting such outcomes.

The findings of the current study also support the need to standardize what specific trainings, opportunities, or advanced degrees science specialists should hold to impart substantial impacts. In the current study, the science specialists used in the selected schools had not completed any coursework related specifically to a science education degree, nor did they hold any job experience in a science-related field outside of K-12 education, although they had engaged in job-embedded science professional development and STEM professional development opportunities. Given the use of archival data in this study, specific details related to the education, training, and experiences of the science specialists, including the number of years that they taught science and the specific methods of instruction they used, in the study was not available and, thus, serves as a limitation to the current study. Future study should explore these characteristics, perhaps through a quasi-experimental study. Further, this highlights a potential challenge within the body of literature and the relatively broad use of science specialists in that standardized requirements for science specialists have not yet been established. Thus, science specialists in one school might hold advanced expertise in science (such as advanced science education degrees) while science specialists in another setting may have only attended science-related workshops.

This is not to say that the use of science specialists is for naught, but rather that the current body of literature has not yet sufficiently defined the criteria required to be a science specialist, how science specialists are being used within schools, and what best practices effective science specialists might utilize. As reiterated within the literature, "one would expect specialists to have deeper science content knowledge and be able to engage students in higher quality science instruction due to some combination of interests and competencies coupled with the ability to focus either on fewer subject areas or on science exclusively" (Brobst et al., 2017, p. 1304).

For instance, previous literature that focused on engaging students in the practices of science found that authentic opportunities were more effective than traditional instruction that focuses primarily on the presentation of content knowledge (Diaconu et al., 2012; Harman et al., 2016). Studies have also supported that elementary science specialists, in general, utilize authentic learning opportunities more often than generalists, which may in turn lead to increased student engagement with science (Campbell & Chittleborrough, 2014). The use of archival data in the current study did not allow the measurement or examination of the specific strategies utilized in instructional delivery by science specialists or by elementary generalists. It cannot be assumed, then, that all science specialists are employing authentic learning opportunities in the classroom or, if they are, to what extent above and beyond what elementary generalists are currently doing. Study is needed, then, to identify specific practices that science specialists might use and, importantly, whether these practices differ substantially from the practices used by generalists.

In the current study, the effect of using elementary science specialists on science achievement was examined while controlling only for prior science achievement measured by one specific assessment—the GMAS. While the use of a standardized assessment to measure student outcomes, especially in relation to the impact provided by the use of science specialists, aligns with previous research (Levy et al. 2016), examination of other student outcomes may be beneficial in understanding whether science specialists influence students' interest in science, engagement in science, or other science outcomes.

Finally, the findings support the need for further examination to include a more specific definition of requirements that science specialists must meet, practices utilized by science specialists and elementary generalists, and the level and quality of supports provided to all educators charged with providing science instruction to elementary students. Evidence supports that science specialists may positively impact science attitudes, frequency of science instruction, interest in science, consistency in science curriculum, increased use of inquiry-based practices, and increased student science scores (Schwartz & Gess-Newsome, 2008). Thus, it would be prudent to determine what factors related to the use of science specialists are impactful given the historical use of science specialists to supplement and support elementary science education. Future study might also examine the impact of a larger number of science specialists and generalists.

Conclusion

The results of this study suggest that the impact of science specialists alone may not be sufficient to produce an increase in the science achievement of elementary students as measured by one science assessment and among one sample population. The results of this study align with other studies and suggest that schools seeking to improve the results of science instruction cannot focus solely on the type of teacher delivering instruction and, rather, should consider the specific practices used in instructional delivery and available resources to support all educators providing science instruction to students.

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