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Examining the Effects of Integrated Science and Literacy Instruction to Teach Second-Graders to Write Compare and Contrast Informational Text

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Abstract
The purpose of this study was to evaluate a form of writing instruction designed to teach second-graders to write compare and contrast informational texts. 73% of the participants ($N=45$) were White, 22% were Hispanic, 2% were Asian, and 1% were Black, with 63% of the students eligible for free or reduced lunch. 48% of the students were female and 52% were male. Data collection included pre- and post-instruction writing samples that were scored using both a holistic and analytic writing rubric. A paired samples t-test revealed statistically significant differences ($p=.000$ for both the holistic and analytic rubric analyses) in student writing scores before and after instruction with a medium ($d=.52$) and large ($d=.95$) effect size reported. These findings suggest that the integrated science and literacy instructional approach supported the second-graders as they learned to write science informational texts that employed a compare and contrast text structure. Because the analytic rubric produced ordinal data, a Wilcoxon Signed Rank Test was used to explore any differences noted for the individual rubric elements. Results in these analyses indicated that there were statistically significant increases from pre- to post-instruction for the use of science vocabulary and definitions, for word count, and for the use of periods. There were no statistically significant differences in the use of signal words to indicate the compare/contrast text structure, in the use of capitals, or an introduction or conclusion.

Keywords Writing instruction · Informational text · Science informational text · Compare and contrast · Text structure · Early childhood writing

Introduction

It is a recognized fact that literacy plays a vital role in helping children experience future success both academically and vocationally (Cutler and Graham 2008; Troia and Olinghouse 2013). The importance of literacy instruction is also reflected in the dominant role it plays in primary grade classrooms, which far surpasses the amount of time spent on other subject areas (Duncan et al. 2011; Trygstad et al. 2013). Surprisingly, writing instruction has been conspicuously missing from most school curriculum reforms to date, and the emphasis on writing instruction in the primary grades historically receives much less attention than reading instruction (Cutler and Graham 2008). Being able to write well is needed as students progress through their education because written work is often the means by which teachers determine student ability and knowledge (Graham 2006). Writing instruction varies across schools and settings in the U.S. as does the amount of writing instruction (Cutler and Graham 2008; Graham et al. 2002). The English Language Arts Common Core State Standards (ELA-CCSS, National Governor's Association Center for Best Practices and Council of Chief State School Officers 2010) have placed a greater emphasis than ever before on the importance of teaching students to produce sophisticated writing products. Shanahan and Shanahan (2014) described the changes reflected in the ELA-CCSS as ambitious goals and expectations for the writing knowledge and skills required of children beginning as early as kindergarten.

One of the more challenging writing products that young children are now expected to produce is informational texts. The 2nd grade ELA-CCSS writing standard includes the

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following: *Write informative/explanatory texts in which they introduce a topic*, *use facts and definitions to develop points, and provide a concluding statement or section*. This type of writing is arguably more complex than writing a narrative or expressing an opinion. In essence, the young writer is expected to write with authority and demonstrate knowledge on a specific topic taken from the natural or social world to share with someone who is less informed (Duke and Bennett-Armistead 2003).

Duke and Bennett-Armistead's (2003) definition provides clues regarding the types of instruction that teachers should consider when teaching young children to write informational texts. First, in order to write informational texts, children will need time to gather information so as to develop expertise on a topic. Thus, children will need opportunities to construct this knowledge. The ELA-CCSS were intended to be taught within the various disciplines and so integrating writing instruction with other disciplinary subjects is recommended (Shanahan 2015; Zygouris-Coe 2012). Next, young children will need support in knowing how to put their ideas into writing while simultaneously using their knowledge of letter sounds and letter formation (Williams 2017). Third, young children will need support in organizing their information and ideas using the specific text structures associated with informational text. Meyer and Freedle (1989) identified the five text structures that are unique to informational text to include sequence, compare/contrast, description, cause/effect, and problem/solution. Finally, young children will need help with formatting their writing to ensure that an introduction and a conclusion are included and that writing conventions (e.g., spelling, punctuation, grammar, and capitalization) have been addressed.

Unfortunately, many teachers express uncertainty about how to teach young children to write (Troia and Maddox 2004). Graham et al. (2015, p. 499) explained that the "CCSS (are) purposefully silent about how the writing benchmarks are to be achieved," and so teachers will need support to teach these writing standards effectively. Further complicating this issue is a dearth of research available on how to teach young children to write and even less research on how best to teach young children to write informational texts specifically (Graham et al. 2015). Graham et al. (2012a, b) stated that teachers will "need effective instructional tools" (p. 879) to meet the demands for the writing expectations outlined in the ELA-CCSS. The purpose of the current study was to evaluate a form of writing instruction designed to teach second-graders to write informational texts.

Literature Review

Theoretical Framework

Vygotsky's (1978, p. 84) social cultural theory describes how "learning and development are interrelated from the child's very first day of life." Vygotsky coined the phrase, "zone of proximal development" to describe the distance between the *actual* developmental ability of the child, or what the child can do independently, and the *potential* developmental ability of the child, or what the child can do with support and scaffolding (Chaiklin 2003). In the primary grade classroom, each child has the potential of being able to write informational texts independently, yet the role of the teacher is critical in supporting children as they learn to write informational texts.

Vygotsky also posited the idea that the accumulation of knowledge is not gathered in isolation from others, nor is knowledge merely transferred or transmitted from one individual to another. Rather, knowledge and learning are socially constructed within groups of individuals using cultural experiences, artifacts, and tools. In the current study, examples of *experiences* consist of the class and peer discussions, books read aloud and discussed, and the science experiments and lessons. Examples of *artifacts* include mentor texts, videos, and books. *Tools* include reading, writing, listening, and thinking as well as computers, paper books, chrome books, digital texts, tools use in science experiments, sticky notes, and paper/pencils used to capture ideas and thinking and more.

With Vygotsky's theoretical framework in mind, we hypothesized that a child must construct the knowledge needed in order to write with authority on a complex topic, all four components of literacy are necessary to do so. Reading and listening serve as the inputs, or the tools used to gather and develop knowledge, while writing and speaking serve as the outputs, or the tools used to share one's thinking and knowledge on a topic.

Recommendations for Teaching Children to Write Informational Text

Reading and Writing

Researchers have long studied the relationship between reading and writing and how one reinforces the other (Berninger et al. 2002). Reading is especially important within this context of teaching children to write informational texts because reading provides a way for children to gather information to write about. Thus, the teacher plays a vital role in supporting young children because they typically cannot read

independently informational texts that frequently use complicated and content-specific vocabulary terms.

Shared reading is a commonly used instructional strategy designed to help young children develop knowledge collaboratively. The shared reading experience becomes a boon to writing instruction when the teacher reads an informational book aloud to the students and students are encouraged to share ideas and thoughts while the book is being read. Unfortunately, researchers have noted how informational texts are not typically selected by early childhood teachers for shared reading, which limits the children's exposure to content-rich words and content area topics (Kuhn et al. 2017; Maloch and Bomer 2013; Yopp and Yopp 2012). Shared reading experiences provide ample opportunities for students to practice complex vocabulary by answering questions in contextualized settings (Beck and McKeown 2007; Penno et al. 2002). Guo et al. (2016) encouraged teachers to incorporate in depth and high quality discussions during shared reading in order to more effectively influence vocabulary growth and development.

Speaking and Listening

According to Vygotsky, speaking and listening are also critical components of learning and development. In *Thought and Language* (2012), Vygotsky explained how private speech or speaking to oneself promotes the development of communication, self-guidance, self-regulation, pacing, and planning. Winsler et al. (2009) explained how the social/cultural tool or symbol system of language is used by children through inner communication first, followed by communication with others later. Kroll's (1981) foundational work also explored the relationship between speaking and writing and asked whether or not "practice in talking is [essentially] practice in writing" (p. 32). More recently, Dockrell et al. (2011) explained that language is the foundation for learning to read and write and is how children make sense of their world. Talk is seen as the means through which children get to know the world, understand complex events, and encounter different perspectives (Resnick and Snow 2009). Thus, the ability to talk about complex science topics is an indication of more sophisticated learning and understanding and preparation for writing.

Researchers have long recommended the value of developing speaking and listening skills in the pre-school classroom (Kendeou et al. 2009; Storch and Whitehurst 2002). A child's oral language has been explicitly linked to future reading achievement and the development of a sophisticated vocabulary (Dickinson and Porche 2011). Everyday conversations become a natural way to stimulate inquiry and wonder about the various science topics. Researchers have noted that conversations among students are beneficial and allow opportunities to practice science terms and vocabulary and to think through and discuss complex science concepts (Parsons and Ward, 2011; Wright and Gotwals 2017). Teachers are encouraged to create positive and conversation-oriented environments so students will feel free to question and discuss their ideas (Mashburn et al. 2009).

However, research has also demonstrated how early childhood teachers do not frequently engage young children in deeper, high quality conversations (Cabell et al. 2015). These findings suggest a need to incorporate more speaking and listening in preparation for writing.

Integrating Science and Literacy

Science is a subject where students are frequently encouraged to construct knowledge based upon inquiry and with plenty of authentic experiences, they are able to contextualize scientific information (Bass et al. 2009). The Next Generation Science Standards (NGSS; Lead States 2013) have made explicit connections between an integrated and seamless literacy and science instruction that is necessary for teaching children to communicate about the natural world in which they live. In their book, Neuman et al. (2007) also highlighted the benefits of integrating science and literacy instruction as a way to strengthen the literacy development in young children.

Researchers have also noted how the integration of science and literacy instruction has specifically helped students develop a speaking or listening vocabulary, which leads to a more developed written vocabulary (Beck and McKeown 2007; Biemiller 2004; Wasik and Bond 2001). As an example, Leung (2008) instituted instruction that included science informational texts for preschool children. In one group, the shared reading experience was followed up with a retelling and discussion about the book while in the other group, the shared reading experience was followed up with science hands-on activities. Leung noted a statistically significant effect on vocabulary outcomes when comparing the two groups with the group receiving science hands-on activities combined with discussions performing better.

In another example, Gonzalez et al. (2010) read 32 science books (informational texts and literature) during shared reading to preschoolers partnered with science-related experiences alongside shared reading, while the second group received the shared reading experience alone. Gonzalez et al. (2010) reported that the group with the science-related learning experiences outperformed the control group on the science vocabulary outcomes. Finally, Neuman et al. (2011) conducted a randomized control study that explored the impact of teaching preschool children vocabulary words within a science (and other content areas) context compared to the teaching of vocabulary words in isolation from content area instruction. Results indicated that children receiving vocabulary instruction in conjunction with

science instruction consistently outperformed their control counterparts in word knowledge and concept development.

Mentor Texts

Mentor texts are texts that resemble the type of texts that students are being asked to write and have been shown to be beneficial for young children (Clark and Neal 2018). Mentor texts "serve as models of how to write well within a genre" (Pytash and Morgan 2014, p. 95). For example, mentor texts for informational writing include text structures and text features unique to this writing genre. These informational texts often include a title, content-specific vocabulary, headings, and sometimes a table of contents, glossary, and other text features. Using mentor texts allows the teacher to point out these text features and structures and writing conventions such as capitalization and punctuation utilized in informational text. Teachers can also use mentor texts to show students *how* to incorporate text structure into their writing, as well as effective word choice, varied sentence structure, and charts, graphs, and pictures in their own writing (Graham et al. 2012a, b). Teachers become the requisite "more capable other" by scaffolding for students the text features unique to informational texts so students can include them in their own writing.

Teaching Compare and Contrast Text Structure

In order to teach children to write informational text, it is important that the teacher considers which text structure to use or to emphasize first when working with young children (Moss 2004). Moss (2004) suggested that teachers teach the sequence or compare and contrast text structures first, as these seem to be easier for young children to discern and recognize within writing. In the current study, the students were taught to write using the compare/contrast structure. Signal words associated with the compare/contrast text structure include some of the following: same, different, similar, and alike.

We were able to locate six studies where researchers specifically examined the process of teaching children to write informational texts using the compare/contrast structure. First, Englert et al. (1991) taught 4th and 5th graders to write sequence, compare/contrast, and problem solution texts using the Cognitive Strategy Instruction in Writing Program (CSIWP). This strategy emphasized planning, organizing, writing, editing, and revising. The students provided with the CSIWP produced higher quality texts. Next, Hammann and Stevens (2003) found that middle school students that were provided explicit instruction that identified specific components of the compare/contrast text structure performed better than those who received only instruction on how to summarize the books they read to gather information on the writing topic. Thus, simply writing about what is read is not the same as taking the information gathered from reading and producing texts from this information.

In another study, MacArthur and Philippakos (2010) taught 6 students between the ages of 11 and 14 years old to plan, write, and revise compare/contrasts essays using the Self-Regulated Strategy Development Model (SRSD) created by Graham and Harris (1993). This instruction produced positive results with the participants producing higher quality writing that reflected greater organization using text structure. These results were maintained 4 to 8 weeks after the study. More recently, Fidalgo et al. (2015) worked with 6th graders to provide teacher modeling and reflection while writing, explicit instruction on writing strategies, practice with peer feedback, and independent practice. With this scaffolding and support, the 6th graders were able to generate texts with higher quality organization and coherence. Similarly, Torrance et al. (2015) worked with 6th grade students and provided strategy training regarding the writing process when students were asked to write compare/contrast text. Students who received this strategy instruction wrote higher quality text when compared to those participants that were part of the control group. Finally, Turgut and Kayaoğlu (2015) employed writing rubrics as an instructional tool to help students learn about the components they would be expected to include in their compare and contrast texts. This instruction produced higher quality texts written by students. One gap noted in the research that specifically examined how to teach students to write using the compare/contrast text structure was that all of the participants have been enrolled in upper elementary or middle school.

Overall, we noted from the studies located in this literature review that children need to be provided with ample opportunities for reading, writing, speaking, and listening to fully develop an understanding and ability to write about complex topics with authority. We also noted the value in integrating literacy and science instruction to provide a natural context for merging these two subject areas and as a means for helping students develop an ability to produce informational texts. Finally, the use of rubrics and mentor texts to provide modeling and scaffolding for the features and structures of informational texts and attending to one of the text structures specifically (in this study the compare and contrast text structure was utilized) was found to be helpful in supporting students in learning to write informational text.

Clearly more research is needed on how best to support young writers in the primary grades. Thus, the goal of the current study was to provide second-grade children with a variety of shared reading experiences, intentional and meaningful conversations, the use of mentor texts, and plenty of opportunities for hands-on integrated science and literacy experiences to teach children to write informational texts that use the compare/contrast text structure. Our goal was to

determine if the integrated instruction had an effect on the quality of second-grade informational texts produced. Our research question was: How does an integrated science and literacy instructional unit influence the quality of science informational texts produced by second-graders as measured by writing rubrics? We hypothesized that writing samples would improve in quality as a result of student participation in the integrated science and literacy instruction and as measured by writing rubrics.

Methods

Setting and Participants

To ensure ethical procedures were followed, approval for the study was granted by the University Institutional Review Board and by the school district. The setting for the study was situated within three second-grade classrooms from one elementary school in a suburban school district located in the Western U.S. In this Title I elementary school, students in grades K-6 were enrolled. The participants in the current study were second-graders ($N=45$) between the ages of 7 and 8 and who were enrolled in the first quarter of the school year. 73% of these students were White, 22% were Hispanic, 2% were Asian, and 1% were Black, with 63% of the students eligible for free or reduced lunch. 48% of the students were female and 52% were male. Only students who participated in all days of instruction and who produced both the pre- and post-writing samples were included in the study.

Three second-grade teachers agreed to participate in the study. Two of the teachers had three years of experience, and one had 20 years of experience. Each teacher received a gift card for her participation. Each teacher was provided with a 3-h professional development on how to implement the lesson plans and instruction and how to use the instructional materials that were provided for hands-on science activities. The first author, who has a background in disciplinary literacy, provided the training. Teaching observations were conducted during each day of instruction by trained research assistants (1-h training) to ensure that there was adherence to the assigned instructional plans and lessons as outlined (for example, see O'Donnell 2008). These fidelity checks were not intended to rate or measure the quality of instruction, but rather to ensure that the instructional activities occurred as outlined in the instructional lessons and materials.

Procedures

Stage One

The first stage of the study took place on the first day of instruction and involved having the students produce a pre-instruction writing sample that was collected by the teacher. Prior to any instruction, the second-graders were provided with the following writing prompt: *How are living and nonliving things the same and how are they different?* This prompt lent itself to using the compare/contrast text structure. Each teacher read the prompt to the children and reread it as necessary. Students were given the writing prompt on a piece of lined paper and a pencil. The students received no support or assistance from their teacher. The children were allotted 30 min to complete the compare/contrast writing prompt, but most students finished within 15–20 min. The purpose of the pre-instruction writing prompt was to see what the second-graders could write when asked to write about a compare and contrast science topic without any instruction or teacher support. The teacher collected all writing samples.

Stage Two

The second stage consisted of teaching the integrated science and literacy lessons. See Table 1 for a sample of the weekly lessons. These lessons took place over the course of three weeks for three days each week, with each lesson lasting approximately 30 min. Shared reading was conducted using digital texts so texts could be displayed for all students to clearly see the elements of writing used in the mentor texts. The local state science standard that was used during the integrated instruction was as follows: *Compare and contrast the characteristics of living things in different habitats*. The ELA-CCSS (2010) writing standard was as follows: *Write informative/explanatory texts in which they introduce a topic*, *use facts and definitions to develop points*, *and provide a concluding statement or section*.

Stage Three

The final stage took place at the conclusion of the science-infused literacy and literacy-only instruction on the last day of instruction. This consisted of having students use the same writing prompt as used during pre-instruction: *How are living and nonliving things the same and how are they different?* Each teacher read the prompt to the children and reread it as necessary. Students were given the writing prompt on a piece of lined paper and a pencil. The students received no assistance from their teacher. The children were allotted 30 min to complete compare/contrast writing prompt, but most students finished within 20–30 min. The purpose of the post-instruction writing prompt was to see what the second-graders could write when asked to write about a compare and contrast science topic after they were provided the integrated science and literacy instruction. The teacher collected all writing samples.

Table 1 Sample of weekly lessons from the integrated science and literacy instruction

Lesson	Lesson/activity
1	In small groups, children observe and examine an inchworm on a paper plate. Students are encouraged to talk aloud (speaking/listening) about what they see, what questions they have, and to record their thinking on a piece of paper (writing) using words or pictures. Afterwards, the children are called to the rug where the teacher holds up a gummy worm. She asks the students to identify the similarities and differences between the living worm and the gummy worm (speaking/listening). Finally, the teacher reads aloud (reading) the book, *What Kind of Living Thing is It*? (see Beck and McKeown 2007; Penno et al. 2002). The teacher tapes a piece of poster paper to the board so the class can identify the similarities and differences between the earthworm and the gummy worm. Teacher and/or students record ideas that are shared
2	Students sit as small groups with a collection of books for students to read (reading) on the topic of living and nonliving things. Teacher creates a new chart on the board that has two columns: Living Things and Nonliving Things. The class meets as a whole group to discuss (speaking/listening) and the teacher records a list of characteristics for Living and Nonliving things that students have learned through observations and books (reading) as evidence to support their thinking (see Guo et al. 2016). Teacher then reads *Living or Nonliving* for shared reading. As a class, the group discusses (speaking/listening) any ideas that needed to be added to their Living/Nonliving chart. Teacher and/or students record and discuss ideas (see (see Kendeou et al. 2009; Guo et al. 2016; Storch and Whitehurst 2002)
3	The children are assigned to work as a group during a scavenger hunt on the playground to locate examples of living and nonliving things. Each group is given an iPad/camera so that they can take pictures of what they find. Small groups are expected to locate five living and five nonliving things. The children discuss (speaking/listening) and take pictures to share on the big screen when they are back in the classroom. Additionally, children are encouraged to prepare their ideas to support evidence for their pictures. Why is this a living thing? Why is this a nonliving thing? (Speaking/listening) (see Kendeou et al. 2009; Storch and Whitehurst 2002)
4	Teacher plays a video (see https://www.youtube.com/watch?v=I_s_1OIEtFc) for the students that portrays examples of living and nonliving things within the environment. Some of these are challenging for young children to discern/understand and so discussion is encouraged (speaking/listening) (see Kendeou et al. 2009; Storch and Whitehurst 2002). Video segments include an icicle, a fire, a river, a seed, a baby chick, etc. Teacher reads aloud *Is it Living or Nonliving?* (Reading) as a shared reading experience for the children. Attention is directed to the science vocabulary words and any compare/contrast signal words used in the text (see Clark and Neil 2018; Graham et al. 2012a, b; Pytash and Morgan 2014)
5	Teacher distributes a picture to each child. The picture depicts a living or nonliving thing. Examples of pictures include a rock, baby, cloud, bunny, pencil, and grass. The children are given lined paper and encouraged to write (writing) about whether the picture represents a living or nonliving thing (see Turgut and Kayaoğlu 2015). While writing, the teacher displays a list of words that might be helpful for students to use in their writing (see Smith and Busch 2016). These words may be science vocabulary words the children have been learning about or they might be signal words associated with the compare/contrast text structure: same, different, in contrast, similar, etc. The children are encouraged to explain in writing why they think this is so. Students share their writing aloud with a partner (speaking/listening) (see Kendeou et al. 2009; Storch and Whitehurst 2002)

Design and Instrumentation

This quasi-experimental study employed a one-group pre/post design (Shadish et al. 2002) using the same group of students at both stages. We made an intentional decision to use two rubrics to score student writing. Both analytic and holistic rubrics have been used in previous research, but we could not find an example of them being used simultaneously. Using both allowed us to determine if the similar results or progress were produced regardless of the rubric in use. The holistic rubric (see "Appendix 1") is currently used as a summative assessment in the state where the study was conducted. The purpose of a holistic rubric is to examine student writing as a whole that considers the content, purpose, and writing conventions located within the student writing to create an overall score. The analytic rubric (see "Appendix 2"), on the other hand, is considered a formative assessment and evaluates each element of the writing sample separately so as to determine specific areas of writing where individual students need assistance and then an entire score is calculated representing a total for each of the respective rubric elements.

For the analytic rubric, we opted to use a weighted rubric so as to emphasize certain rubric elements in the writing analysis over other rubric elements that were not emphasized as heavily during instruction. This practice is supported in previous research that has explored the effectiveness of writing instruction and the use of writing

rubrics (Dickinson and Adams 2017; Pate et al. 1993; Wolf and Stevens 2007). First, word count or length of the writing sample received more weight as it has been identified by many researchers as being the area where much of the variance is found when comparing writing samples (Morphy and Graham 2012; Page and Petersen 1995; Purcell-Gates et al. 2007). The other two rubric elements that received more weight in the analysis were the student's use of signal words to indicate compare/contrast text structure, and the number of science definitions and facts included because these elements were a specific focus of the targeted instruction. These three rubric elements were each weighted at 20% because they were emphasized the most during daily instruction.

Additional elements were explored using the analytic rubric but these were not weighted as heavily because they were not emphasized as strongly during the instruction as evidenced by the lesson plans and the fidelity checks. These elements included use of an introductory sentence, a concluding sentence, capitalization, and ending punctuation. Each of these rubric elements were weighted at only 10% in the analytic analysis. Therefore, each rubric element was weighted as follows: use of signal words demonstrating text structure (20%), word count (20%), facts, definitions (20%), number of capitals used at the beginning of sentences (10%), number of punctuation marks used at end of sentences (10%), inclusion of introductory sentence (10%), and inclusion of concluding sentence (10%).

Data Analysis

Two researchers scored the pre- and post-instruction writing samples. Before scoring, the researchers discussed the rubric and scored one writing sample together and discussed their reasons for choosing rubric scores to ensure there was agreement about what the rubric wording meant. Next, the raters scored the remaining writing samples separately and a Cohen's Kappa was used to determine inter-rater reliability between the two raters. Next, we used a paired samples *t*-test to determine any differences from pre- to post-instruction for both the holistic and analytic rubric scores and employed the Cohen's d (Cohen 2008) to determine the effect size of these results. Finally, A Wilcoxon Signed Ranks Test was used to explore the differences in student writing from pre- to post-instruction for each individual rubric element on the analytic rubric. This test was selected because both sets of rubric scores were ordinal data and so a nonparametric test is recommended (see Kuzon et al. 1996; Stevens 1946). We followed Stevens' recommendation to report the median instead of the mean when reporting the descriptive statistics of ordinal data. Significance in this study was set at $p < 0.05$ and the rubric scores indicated a normal distribution.

Results

The findings that emerged from the paired samples *t*-test using the scores from the holistic rubric indicated that there was a statistically significant difference in student writing scores from the pre- ($M = 1.55$, $SD = 0.58$, range = 0 to 3) to post-instruction ($M = 1.87$, $SD = 0.65$, range = 0 to 4); $t(45) = 19.403$, $p = 0.000$). A Cohen's d effect size for these results indicated a medium effect size at 0.52. Similar findings were found when analyzing the scores from the weighted analytic rubric indicating that there was a statistically significant difference in student writing scores from the pre- ($M = 0.88$, $SD = 0.82$, range = 0.00 to 3.00) to post-instruction ($M = 1.76$, $SD = 1.02$); $t(45) = 11.609$, $p = 0.000$). The range of scores was from 0.00 to 3.60). A Cohen's d effect size for these results indicated a much larger effect size at 0.95.

The results from the Wilcoxon Signed Ranks Tests that were used to compare the analytic rubric scores for each individual rubric element indicated that there were

Table 2 Descriptive and inferential statistics for individual elements of the analytic rubric

Rubric element	25th Percentile Pre/post	50th Percentile Pre/post	75th Percentile Pre/post	Z score	p value
Text structure	.00/.00	.00/.20	.20/.40	−1.687	.09
Science vocab use	.00/.00	.00/.40	.20/1.0	−4.059	.00*
Word count	.00/.40	.20/.80	.40/1.0	−4.769	.00*
Capital use	.00/.00	.10/.10	.10/.20	−1.013	.31
Period use	.10/.05	.10/.20	.20/.45	−2.539	.01*
Intro sentence	.00/.00	.00/.00	.00/.00	.000	1.0
Conclusion	.00/.00	.00/.00	.00/.00	−.557	.57

*Statistically significant

statistically significant increases from pre- to post-instruction in student use of science vocabulary and definitions, in the word count or length of student writing samples, and student use of periods at the end of sentences. There were no statistically significant differences noted for students using signal words to indicate the compare/contrast text structure, students using capitals at the beginning of sentences, or students including an introduction or conclusion. See Table 2 for these descriptive and inferential statistics from the Wilcoxon Signed Ranks Tests.

Discussion

The results of the current study indicate that the integrated science and literacy instruction that incorporated mentor texts, hands-on science experiments and activities, along with daily opportunities for reading, writing, speaking, and listening are likely to produce significant gains in student writing from pre- to post-instruction using both writing rubrics. The observed changes in children's writing samples from pre- to post-instruction was substantial, regardless of the rubric being used, with a medium and large effect size reported. These findings are encouraging as they suggest that an integrated science and literacy approach allows students to develop a deeper understanding of science topics as demonstrated by both their increased use of science vocabulary and definitions in their writing as well as the longer writing samples produced as measured by the overall word count. While length of text does not necessarily guarantee quality writing, Purcell-Gates et al. (2007) stated that word count in the writing for young children is an indicator of quality.

These findings align with those from previous research where the positive results that occurred when teachers integrated science and literacy instruction (see Beck and McKeown 2007; Biemiller 2004; Wasik and Bond 2001). Researchers have already demonstrated how science knowledge increases (see Gonzalez et al. 2010), how vocabulary use improves (see Leung 2008), and how word knowledge and conceptual development increases (see Neuman et al. 2011) when teachers integrated science and literacy instruction. In this study, evidence of student knowledge growth and vocabulary use was documented in the writing samples.

The findings of the current study are important because they help us understand more fully the developmental needs of young writers and provides ideas for how to provide the necessary scaffolding and support to young children. As Vygotsky (1978) explained, social interactions allow students to improve their ability to ask questions, to communicate, to solve problems, and to build a more advanced understanding about life. Vygotsky explained that as children cognitively develop, their abilities and understandings develop as well. Thus, with the scaffolding and support provided in the current study, we can see how these young children are able to develop not only in their understanding and knowledge about science topics but also in their ability to write about their ideas and this newly acquired knowledge as well.

Moreover, the deeper analysis that was afforded by using the analytic rubric in addition to a holistic rubric suggested that students also grew in their writing knowledge and specifically the importance of using a period at the end of the sentence. We attributed this growth to the use of mentor texts where the children were able to see the ending punctuation modeled repeatedly each time a mentor text was read and shared. Similarly, these findings align with other studies that indicate the support that mentor texts provide students while they are learning to write is highly beneficial (Clark and Neal 2018; Pytash and Morgan 2014). Unfortunately, the integrated instruction did not seem to have an effect on how well students remembered to include signal words indicating the compare/contrast text structure, capitals at the beginning of sentences, or an introduction or conclusion. It is clear that more research is needed to assist young children as they learn to write complex informational texts that incorporate these important elements of writing. One observation that was noted during the teaching observations was that many of the informational texts used as mentor texts did not always include an introduction or conclusion, and so this may have impacted the young children remembering to do so. The lack of an introduction or conclusion in children's books has also been noted in a content analysis study of informational texts geared for the primary grades (Jones et al. 2016).

Future Research

These findings raise important questions and ideas to be considered in future studies. First, how much exposure do young children need with complex science topics and concepts and texts before they can write high quality science informational text? The current study only lasted three weeks. Though this is the standard amount of time that the teachers

in the current study spent on their typical writing instruction units, we wondered if more time would have produced even more robust writing samples. Second, are there sufficient science informational texts available that are available to use when teaching the types and formats of writing and the use of text structures expected of young children (e.g., books that model the use of an introductory and concluding sentence)? Preliminary research in the form of a content analysis conducted by Jones et al. (2016) suggests that many more mentor texts are needed—especially those written for young children who are expected to read and write about complex topics.

While the number of studies examining how to teach young children to write informational texts is limited, this study provides a foundation upon which future studies can build. First, it is recommended that in future studies, other text structures be examined besides the compare/contrast text structure. Second, a future study that includes a more diverse sample than the one provided in this study would be important to consider, as well as studies that include students from different grade levels other than second-grade students—especially work with children in first grade and kindergarten where writing skills are only beginning to emerge. Finally, future work should consider how this type of instruction from the start of schooling might impact students' learning trajectories over time and throughout their schooling in the area of writing.

Limitations

While these findings are promising, there are several limitations to the current study. First, the integrated science and literacy instruction took place in only three classrooms and within only one school district. Therefore, this curriculum will need further adaptation to accommodate various and disparate instructional contexts. Moreover, students within the study sample that had an Individual Education Plan (IEP) or who were identified as English learners were not made known to the researchers. So, another limitation is that we do not know specifically how this integrated science and literacy instruction impacted these particular students.

Additionally, we did not have a control group to compare writing scores with and this component would provide causal information about the impact of the treatment. A control group allows the researcher to determine the effectiveness of instruction when compared to other forms of instruction, including the regular instruction provided in the classroom. Furthermore, as students naturally develop in their writing ability over time, it is possible that these results may have occurred even without the instruction. Thus, a longitudinal study would provide even more information.

Finally, we noted that in future studies, students should be allowed to create multiple drafts of science informational texts before producing their final writing sample. In our study, students were only asked to create a pre- and post-instruction writing sample. This limited our understanding on how students develop in their scientific knowledge and in their writing over incremental stages of time.

Conclusion

This study expands our understanding of how teachers can support young children as they learn to write informational text. The current study provides evidence that second-graders can engage in complex science topics and produce science informational texts that demonstrate their knowledge, understanding, and their developing science vocabulary. As teachers begin to explore ways to infuse more opportunities for speaking, listening, reading, and writing within an integrated science and literacy instructional approach, we encourage them to consider a combination of shared reading, mentor texts, hands-on science experiences, and opportunities to discuss their ideas with peers and adults. These activities helped facilitate the construction of student background knowledge and the ability of second-graders to share this newly developed knowledge about a complex science topic in their own writing. We encourage literacy researchers to further explore how teachers can help young children further develop their writing abilities and to support learning goals centered on writing.

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Appendix 1

Informational text writing rubric for 2nd grade

Score	Statement of purpose/focus and organization (4-point rubric)	Conventions/editing (2-point rubric begins at score point 2)
4	The response is fully sustained and consistently and purposefully focused: • Strong, clear introduction to the topic • Uses 3 or more facts about the topic and interweaves them seamlessly • Provides a concluding statement or section that reiterates the key points	
3	The response is adequately sustained and generally focused: • Introduces the topic • Uses two or more facts and definitions to develop points • Provides a concluding statement or section	
2	The response is somewhat sustained and may have a minor drift in focus: • Unclear or unfocused topic • Confusing or irrelevant facts about the topic • Minimal or absent concluding statement or section	The response demonstrates an adequate command of conventions: • Consistent and correct use of punctuation, capitalization, and spelling • Uses a combination of simple and compound sentences • Capitalizes the holidays, product names, and geographic names • Uses an apostrophe for contractions and possessives • Uses commas in dates and to separate single words in a series • Uses conventional spelling for words with common spelling patterns and for frequently occurring irregular words • Some errors in usage and sentence formation are present, but no systematic pattern of errors is displayed
1	The response may be related to the topic but may provide little or no focus: • No stated topic • No facts included • No sense of closure	The response demonstrates partial command of conventions: • Errors in usage may obscure meaning • Inconsistent use of punctuation, capitalization, and spelling
0		The response demonstrates a lack of command of conventions
NS	Insufficient, illegible, foreign language, incoherent, off topic, or off-purpose writing	

Appendix 2

Informational text writing analytic rubric (second-grade)

Rubric element	Definition	Pre	Post
Text structure: the student uses signal words to indicate text structure	Student uses *four or more* signal words	4	4
	Student uses *three* signal words	3	3
	Student uses *two* signal words	2	2
	Student uses *one* signal words	1	1
	No signal words used	0 × .20 =	0 × .20 =
Content: the student includes facts and details about the topic	Student provides *four* or more facts on the topic	4	4
	Student provides *three* facts about the topic	3	3
	Student provides *two* facts about the topic	2	2
	Student provides *one* fact about the topic	1	1
	Students provides no facts about the topic	0 × .20 =	0 × .20 =
Word count: the student's text uses this number of words in response to the writing prompt	50 Words or more written	4	4
	40–49 Words written	3	3
	30–39 Words written	2	2
	20–29 Words written	1	1
	0–19 Words written	0	0
	Total number of words	× 0.20 =	× 0.20 =
Capitals: the student uses capitals at the beginning of their sentences	Four capitals at the beginning of the sentences	4	4
	Three capitals at the beginning of the sentences	3	3
	Two capitals at the beginning of the sentences	2	2
	One capital at the beginning of the sentences	1	1
	No capitals at the beginning of the sentences	0 × 0.1 =	0 × 0.1 =
Punctuation: the student uses punctuation, e.g., periods, at the end of their sentences	Four or more punctuation marks at the end of sentences	4	4
	Three punctuation marks at the end of sentences	3	3
	Two punctuation marks at the end of sentences	2	2
	One punctuation mark at the end of sentences	1	1
	No punctuation at the end of sentences	0 × 0.1 =	0 × 0.1 =
Introduction: the student includes an introduction	Strong, clear introduction to the topic has been included	4	4
	Introduction has been included	3	3
	Introduction is included, but not focused or unclear	2	2
	It is unclear whether an introduction was included	1	1
	No introductory sentence is included	0 × 0.1 =	0 × 0.1 =
Conclusion: the student includes a conclusion	Includes a clearly stated concluding sentence	4	4
	Includes an acceptable concluding sentence	3	3
	Includes a concluding sentence that is not on the main idea	2	2
	Includes an incomplete conclusion sentence	1	1
	No conclusion is included	0 × 0.1 =	0 × 0.1 =
Overall rubric total			

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