EARLY ELEMENTARY INTEGRATION ACROSS THREE DOMAINS: INQUIRY SCIENCE, MATHEMATICS, AND LANGUAGE DEVELOPMENT [GRADES K-1]

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Overview

It is no secret that science education in the majority of US school districts is underprioritized, predominantly in the elementary grades. In most cases, if science is even taught, it is in one- or two-week surface level units that do not attempt to connect to student prior knowledge or extend learning into students' worlds beyond the classroom. Given my position as a professional student research assistant here at Vanderbilt, I frequently worked with local Metro Nashville elementary school teachers involved in a research program to increase their knowledge about using representations in science. One concern that these teachers commonly voiced was the lack of time that they had to teach science; some reported times as little as 15 minutes per day. Towards the end of one video club meeting, I distinctly remember a teacher saying he wished that he had as much time for science as he did for math. It was at that moment that I decided to focus on elementary science and mathematics integration as a way to increase time spent teaching science. Over time, I recognized the importance of including language development strategies for English learners in my design as many of the teachers in my context had these students in their classrooms. Ultimately, as informed by my problem of practice and context, I established the research question: *How can early elementary science and mathematics standards and practices be integrated with language development strategies to increase time spent on science instruction and students' conceptual understanding*?

Related Research

NCLB Effects on Elementary Science Education

Since the passage of the No Child Left Behind (NCLB) Act in 2001, science education in elementary school classrooms has been placed on the back burner to make room for district required, national standards-based curricula in literacy and mathematics. As a direct result of NCLB, the federal government increased its involvement in public education and required "that all states annually assess students in Grades 3 through 8, set ambitious and uniform improvement goals for their schools, and prescribe sanctions for schools that failed to meet these goals" (Goertz, as cited in Meyers, 2012, p. 475). Tracking improvement in regard to these 'ambitious and uniform' goals led to the vast quantification of education by measuring achievement based on standardized test scores specific to literacy and mathematics. According to a four-year study from the Center on Education Policy (CEP), "seventy-one percent of the school districts [they] surveyed reported that they have reduced elementary school instructional time in at least one other subject to make more time for reading and mathematics—the subjects tested for NCLB" (Center on Education Policy (CEP), as cited in Griffith and Scharmann, 2008, p. 35). Consequently, the amount of time spent on science instruction in the elementary grades decreased significantly. In research specific to the initial impact that NCLB had on elementary science education, Griffith and Scharmann (2008) indicated that "roughly 50% of the teachers who cut time from science removed between 31 and 60 minutes per week, with another nearly 20% cutting between 61 and 90 minutes per week" (p. 44). In short, NCLB has had negative effects on elementary science education, reducing time spent on science instruction in order to increase time spent on disciplines mandated by state testing. Integrating science instruction with one of these mandated disciplines, in the case of this design mathematics, would create a time and space for teachers to increase science instruction.

Commitment to Science Instruction

Equally troubling as the reduction in time spent teaching science are administrators' and teachers' attitudes and commitment to the importance of elementary science education. According to Griffith and Scharmann (2008), teachers, in response to an open-ended survey question about the importance of elementary science education, stated that "when science becomes part of the yearly state assessments, [we] will have to spend more time on it" (p. 44). According to Milner, Sondergold, Demir, Johnson, and Czeriak (2012), "in general, elementary teachers saw the benefit of making science relevant to their students and meeting state and national standards, but there were many perceived impediments to teaching science including those commonly reported in educational literature including lack of time, resources, and materials as well as the lack of professional development (p.127). Even though many teachers saw the benefit of teaching science, "a number of teachers felt that state pressures to teach mathematics and reading discouraged the teaching of science" (Milner et. al, 2012, p.120). In the same study, it was "found that teachers' beliefs were more influenced by their administration and peer group than they were by federally mandated policy" (Milner et. al, 2012, p.127). Overall, it may be concluded that providing teachers with resources to aid them in integrating science instruction with one of the mandated subjects such as mathematics would clear a pathway for them to pursue the teaching of science that they believe would benefit their students.

Science and Mathematics Integration

In 2012, the National Research Council published *A Framework for K-12 Science Education* which made it "clear that for today's students to become the scientifically literate citizens of tomorrow their educational experiences must help them become mathematically proficient" (NRC 2012, as cited in Mayes and Koballa, 2012). The *Framework* focuses on "important practices, such as modeling, developing explanations, and engaging in critique and evaluation" and "mathematics is fundamental to modeling and providing evidence-based conclusions" (NRC 2012; Mayes and Koballa, 2012). In making connections between the *Framework* and the Common Core State Standards for Mathematics (CCSS-M), Mayes and Koballa (2012) found various parallels between the mathematical practices and the science and engineering practices. Similar practices are the foundation of both disciplines; for example, "developing students' ability to ask well-formulated questions is basic to both science and engineering (Practice 1) and mathematics (Practice 1" (Mayes and Koballa, 2012). Some practices are also addressed simultaneously; for example, the science and engineering practice of planning and carrying out investigations in combination with "collecting data [has] the potential to engage students in all the mathematical practices (Mayes and Koballa, 2012). More generally, "both the *Framework* and the CCSS-M emphasize student construction of conceptual understandings and the development of real-world practices" (Mayes and Koballa, 2012). To sum up, both science and mathematics instruction ground their roots in the same practices, meaning teachers could essentially engage students in both sets of practices simultaneously given the proper the resources and support.

Science and Language Development Integration

Traditional approaches to language development for English learners often takes place in context-reduced instruction because it is assumed that English language proficiency is a prerequisite for subject matter learning. This decontextualized form of instruction leaves English learners in a world of meaningless words because it lacks an authentic context for language use (Stoddart et. al., 2002, p. 666). According to Stoddart et. al. (2002), "inquiry-based science is a particularly powerful instructional context for the integration of academic content and language development for English language learners" because it "promotes students' construction of meaning through exploration of scientific phenomenon, observations, experiments, and hands-on activities, [providing] an authentic context for language use (NRC, 1996 as cited in Stoddart et. al., 2002, p. 665). Contextualizing the use of language within inquiry-based science instruction also nurtures the understanding of science concepts because "the heart of the approach is for students to formulate questions about phenomena that interest them; to build and criticize theories; to collect, analyze and interpret data; to evaluate hypotheses through experimentation, observation and measurement; and to communicate their findings. (Roseberry et. al., 1992, p. 65, as cited in Stoddart et. al., 2002, p. 667). In essence, language development for English learners that occurs within an authentic context for language use, such as the science classroom, supports the development of language and concurrently increases opportunities for conceptual understanding as inquiry-based instruction and the science and engineering practices by design readily nurture the comprehension of science concepts.

Language Development Strategies

Cervetti, Kulikowich, and Bravo (2015) conducted a study to "examine the hypotheses that the presence of educative curriculum features focused on strategies for use with ELLs would increase the number and diversity of strategies that teachers used, would lead teachers to add new strategies to their pedagogical repertoires, and would increase the quality of the instructional strategies teachers used to support ELLs in science" (p. 94). The results of this study indicated that educative curriculum materials encouraged teachers to do more to modify the curriculum to support the English learners in their classroom and used a wider range of strategies (Cervetti et. al., 2015). Although the results of the study did not present a substantial impact on student learning, educative curriculum materials that lay out strategies for supporting English learners understanding of science could also have a positive impact on ELs experiences with science, allowing them more opportunities to construct and strengthen science identities. To summarize, offering teachers a resource that suggests strategies for language development in science instruction may incite them to expand their repertoire of strategies that they use in supporting English learners in the science classroom.

Context

Several elementary teachers from the local Metro Nashville Public School District involved in a research study to increase their knowledge about using representations in science embodied the context for this design. As mentioned in the overview, my position as a professional student research assistant provided access to this context as I attended professional development workshops, video clubs, transcribed interviews, and coded data for this research study. The teachers commonly voiced their concern with the lack of time that they had to teach science; on average they had about 25-30 minutes a day while some reported times as little as 15 minutes per day. According to one first-grade teacher:

> We don't teach science... I have all these awesome ideas...We just don't, it's not in the schedule, and been discouraged from doing science. [By your administration?] Yeah. [Because they care more about...] Literacy, and then math (Anne, personal communication, May 2019).

Connecting to research mentioned above by Milner et. al. (2012), teachers in my context admitted to feeling pressured by administration to cut time for science instruction and increase time for mathematics and literacy instruction. Teachers also expressed that, even in the time that they do have for science instruction, they feel that:

> Our science standards, our science kits that come... it feels like they stand alone or maybe we just aren't able to incorporate them in the way that they could be... So, being able to integrate, being able to connect that with the things we're doing and finding ways to be creative myself with science... build up my toolbox for presenting that knowledge and helping kids find joy in it which is what I want for all their learning (Soren, personal communication, May 2019).

Above, Soren (pseudonym), a kindergarten teacher explains that she joined this research study with Vanderbilt to learn how to "integrate, being able to connect that [science] with the things we're doing" and "build up her toolbox" for presenting science content knowledge (personal communication, May 2019). In observing and transcribing interview data, I also noticed that teachers are already thinking about mathematics in their science lessons, whether it is intentional or not. Anne (pseudonym), a first-grade teacher describes:

> The measurement component of the puddle activity...we kind of talked about the idea of hot gluing unifix cubes on a ruler, and then they could do it that way. I mean, we have only a centimeter of change in our puddle today. And you wouldn't see that at

> all...actually, we could do, we could hot glue, ones from like a base 10 block set, so that could work (Anne, personal communication, May 2019).

In this lesson that Anne explained, students were using relative measurement to monitor the size a of a puddle that was evaporating in their classroom. To reiterate the research reviewed above, “collecting data [has] the potential to engage students in all the mathematical practices (Mayes and Koballa, 2012). This is just one example of how easily mathematics standards practices could be integrated with science instruction. Lastly, Jack (pseudonym), describes why he uses representations in science instruction as a strategy to support English learners:

> [The representations] really brought into vocabulary, the pictures allowed for— if I, if I was an EL student, the pictures would have allowed me to understand what some of that vocabulary was and make connections to that vocabulary with a picture (Jack, personal communication, May 2019).

Using representations, such as pictures like Jack mentioned, as a strategy to support English learners in science instruction is one of the many strategies suggested by Cervetti et. al. (2015) in the research mentioned above. Considering the concerns and implied needs of the teachers in my context paired with the problem of practice and relevant research led to the creation of my informed design.

Informed Design

Informed by the context and related research described above, I set out to construct a resource guide to assist teachers in planning integrated science and mathematics lessons at the early elementary level. This design underwent several iterations before becoming the finished document attached to this analysis. Earlier iterations of this design did not include the language development strategies for English learners. This change came after reading a study by Rodriguez (2015) in which he posed the argument that a dimension of equity is missing from the most recent science reform.

> In addition, just as every NGSS for every grade level includes tables illustrating the knowledge and scientific/engineering practices expectations for each dimension, a dimension of engagement, equity and diversity could have illustrated how the science content could have been made more culturally and socially relevant. A dimension of engagement, equity and diversity embedded in the NGSS would also make it easier for those of us interested in cross- cultural education to counter any resistance to ideological and pedagogical change because it would make quite obvious that equity and diversity are elevated to the same importance as all the other dimensions of the NGSS. (p. 1042).

I decided that the design would not be complete without an element of equity embedded throughout and accordingly adjusted the design to lay out integration ideas across the three domains of elementary science, mathematics, and language development.

The final design presents integration suggestions for each of the disciplinary core ideas (DCIs) taught in kindergarten and first grade as per the Tennessee Academic Standards for Science. The standards associated with each DCI were paired with relevant mathematics standards from the equivalent grade level as identified in the Tennessee Math Standards. In both the Tennessee Academic Standards for Science and Tennessee Math Standards documents, there are suggestions for literacy skills necessary for science/math proficiency. The English learner specific strategies obtained form Cervetti et. al. (2015) were thus divided into categories to mimic the suggested skills recognized in the Tennessee standards documents. Also included in this resource document are recommended science and engineering practices (SEPs) and crosscutting concepts (CCCs) from the Tennessee Science Standards Reference guide, another resource that teachers in the described context are familiar with using to inform their instruction.

Looking ahead, I plan to further improve the language development strategies listed in the current design to more accurately address the varying standards and practices accompanying each of the disciplinary core ideas. I hope that this resource that I designed, in its current and possible future state, will assist teachers in integrating science instruction into their already persistent mathematics instruction and simultaneously encourage them to employ a wider variety of language development strategies to engage their English learners in science content.

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