Integrating Science and Literacy with Early Childhood English Language Learners

Jillian M. Currie

Vanderbilt University

Abstract

There is a current trend of reducing the amount of classroom time devoted to science in order to provide additional time for math and literacy instruction in elementary school classrooms. However, the practice of doing science is increasingly valuable, especially for young English Language Learners. The processes of science allow young children to have meaningful purposes for engaging in language and literacy practices. By integrating science and literacy curricula, educators will be able to devote an appropriate amount of time to science education while continuing to support children’s language and literacy development. Nonetheless, the literature on integrating science and literacy curricula in early childhood classrooms is limited. Therefore, this paper serves several purposes. First, it defines the various perspectives on science, literacy, and integration. Then, a review of the literature on effective teaching practices for young English Language Learners is presented to demonstrate how young English Language Learners benefit from integrating science and literacy instruction. Next, this paper examines the current research and theory on curricular methods for integrating science and literacy content areas in upper elementary school classrooms. Then, strategies for integrating science and literacy in classrooms of preschool and kindergarten age English Language Learners are presented. Next, implications for assessment that arise from adapting the recommended strategies are discussed. Lastly, limitations and future research directions are presented.

**Integrating Science and Literacy with Early Childhood English Language Learners**

The topics of immigration, education, and young children can be found in the news media on a daily basis. As a nation, we are constantly thinking about and trying to find solutions to the pressing issues of closing achievement gaps, educating the nation’s youngest children, and educating students whose first language is not English. Included in these issues is the need to teach young English Language Learners (ELLs) both the English language as well as academic content.

Many early childhood classroom experiences center on literacy and mathematics instruction. Classrooms with young English Language Learners must also focus on English acquisition. Too often in classrooms time designated for science is reduced and replaced with more time spent on math or literacy instruction (McMurrer, 2008). Moreover, students’ science education frequently consists of learning the academic language associated with science with the occasional experiment residing on the periphery (Marx & Harris, 2006). However, in early childhood English Language Learner classrooms, doing science is especially important because it allows for students to engage in hands-on learning, role-playing, and encounter new language labels that can be mapped onto objects and concepts as the children are exposed to them firsthand. Including integrated science and literacy curriculum in early childhood classrooms will allow teachers to justify spending classroom time on science and will allow students, particularly English Language Learners, to take part in scientific processes, engaging conversations that develop language and vocabulary, and meaningful early literacy experiences.

This paper loosely builds upon previous work, which described a theoretical framework for an integrated science and literacy curriculum, completed as part of an independent study. The previous work focused on learning theory and described the specific extracurricular learning context. This work expands upon the concept of integrating science and literacy by providing a review of literature on the topic and by recommending practices for integration to classroom teachers. In this paper, definitions of integration and science will first be discussed. Next, the benefits of science education for English Language Learners are provided. Then, literature on methods for integrating science and literacy curricula will be discussed. Lastly, recommendations for integration methods in early childhood English Language Learner classrooms are provided followed by a brief discussion on the impact the recommendations have on assessment.

**Engaging in Science**

 The concept of doing science evokes many different images from people. Some may think of memorizing science textbooks while others think of experimentation in a chemistry lab. Research, however, supports three different views of science: science-as-logic, science-as-theory change, and science-as-practice, all of which are discussed in Lehrer and Schauble (2006). Science-as-practice is the view used in this work and will be presented more thoroughly.

 The science-as-logic perspective emphasizes the practices of logical reasoning and heuristics that are used across multiple domains of science. The research emphasizes the ways in which children develop strategies for generating and interpreting evidence. Because the research from this perspective focuses on thought processes involved in science, it is too narrow a focus to use as a lens for discussing practices for integrating literacy practices.

Science-as-theory change, on the other hand, focuses on the ways in which naive theories are replaced by new theories about how the world works. Research from this perspective often contains domain-specific knowledge development. Due to the specificity of content, it would be a challenge to use this theory as a lens for integration.

 Science-as-practice is a multi-faceted perspective on the concept of science. Lehrer and Schauble (2006) provide a definition of science-as-practice with examples from the field. The science-as-practice view includes concepts such as theory change and reasoning, but the view also recognizes that the practice of science occurs within a particular community of practice that requires specific forms of talking and writing. There is a focus on the many different forms of representing scientific data and the ways of measuring variables. The science-as-practice perspective includes the science-as-theory and science-as-logic perspectives but goes beyond their definitions to include the procedures involved in acts such as scientific experimentation and comparative analysis.

 While all three perspectives have value to the ways in which science development is studied, the science-as-practice perspective is adopted in this work because the definition of science is comprehensive of the many skills involved in practicing science. Therefore, when science is used it refers to multiple ways of thinking, talking, and representing, and it includes the procedures and practices that occur when people engage in making sense of the world.

**Literacy in the Early Childhood Classroom**

 Literacy, as it relates to language arts, has many definitions. A widely accepted definition is as follows:

[The] ability to read and write in a designated language, as well as a mindset or way of thinking about the use of reading and writing in everyday life. It differs from simple reading and writing in its assumption of an understanding of the appropriate use of these abilities within a print-based society. Literacy, therefore, requires active, autonomous engagement with print and stresses the role of the individual in generating as well as receiving and assigning independent interpretations to messages (Venezky, 1995, p. 142).

While the above definition represents the goal of literacy instruction, it is important to think about the development of literacy for the specific learning context of preschool and kindergarten age English Language Learners. The following paragraphs adapted from Gentry (2006) provide a brief description of the reading and writing levels that are likely to be present in this learning context so that later recommendations can be contextualized.

**Early Reading Development**

 At the very earliest stages of reading development, children are beginning to notice print in their environments and recognize that it carries meaning though they do not attend to the alphabetic information contained in the print at first. Later, children begin to attend to the letter-sound correspondence in print, usually the beginning and ending letters, and use that information to read the word. Next, children use all of the letters in the word to read the word allowing them to distinguish between similarly spelled words. Lastly, children begin to decode words by using common grouping of letters, or chunks, which allows for greater automaticity in reading (Gentry 2006). During independent reading in these stages, much effort is placed on learning to read and less emphasis is placed on reading to learn new information.

**Early Writing Development**

At the beginning of children’s writing development, children engage in writing without letters, which is typically characterized by scribbles or wavy writing. Typically by the middle of kindergarten children will begin to write in strings of letters that do not match with the sounds in the word they are writing. Then, usually by the end of kindergarten, children are using the beginning and ending sounds of words to represent the word (Gentry, 2006). For example, *dog* might be spelled *dg.* Knowing the stages of early reading and writing that children progress through during preschool and kindergarten is important for understanding how later recommendations for integrating science and literacy curricula facilitate early literacy development.

**Integrating Literacy and Science**

 There are three central ways in which integration of subject matter domains have been discussed in the literature: thematic instruction, interdisciplinary instruction, and integrated instruction. The different philosophies allow for varied levels of science engagement as it has been defined in this paper. Each of the philosophies is explicated below followed by a brief example of how the philosophy might occur in practice.

In thematic instruction, the educator chooses a specific theme (e.g. plants) and relates all activities to that theme often “without regard to the objectives and goals of individual disciplines” (Dickson & Young, 1998, p. 335). Often, in elementary school classrooms, language arts activities are chosen to fit a science theme but science practices will not be learned (Dickson & Young, 1998). For example, a teacher might choose books about plants to read, have students plant a seed, and create math word problems that involve selling flowers. In thematic instruction, the subject matter skills are not necessarily integrated although both subjects are connected through the thematic topic.

 Interdisciplinary instruction is similar to thematic instruction in that there is a clear boundary for each subject discipline. However, in interdisciplinary instruction “content and processes in a secondary domain are used to support learning in the primary domain” (Stoddart, Pinal, Latzke, & Canaday, 2002, p. 667). For example, students might make notes in a science journal to better understand what type of soil makes a plant grow fastest. In this example, writing is used to compliment the primary goal of understanding the science concept.

 Integrated instruction differs significantly from thematic and interdisciplinary instruction. In integrated instruction there is no distinction between subjects, and there is balance among domains so that no domain is dominant. Furthermore, Huntley (1998) describes integrated instruction as “a synergistic union of the two disciplines, the result being an activity or curricular unit in which the interactions between the disciplines result in students learning more than just the…content contained therein” (p. 322). Therefore, integrated instruction will allow preschool and kindergarten aged English Language Learners to engage in scientific thinking and processes while also learning literacy and language skills. For example, students might participate in the design of an experiment and construct written methods for documenting the results. It is quite possible for integrated instruction to include multiple domain areas beyond science and literacy; however, the scope of this paper is limited to science and literacy domains. For the purposes of this paper, integrated science and literacy curriculum refer to the set of learning activities created using an integrated instruction philosophy.

**The Case for Integrated Science Curriculum for English Language Learners**

A review of the literature on effective teaching practices for young English Language Learners was conducted to determine if young English Language Learners would benefit from integrating science instruction. Effective teaching strategies with young English Language Learners included the use of “visuals, hands-on learning, gestures, labels, a print rich environment… [and] role-playing…” (Lake & Pappamihiel, 2003, p.202). Additionally, Lake and Pappamihiel (2003) discuss the importance of firsthand experiences for English Language Learners because the firsthand experiences promote language interactions with adults and peers. They further state that children’s literature is powerful in supporting the above mentioned language interactions between adults and peers. Because scientific experimentation allows children to engage in firsthand experiences and because integrating science and literacy curricula allows for the use of effective teaching practices such as labels, a print rich environment, and scientific and children’s literature, there is logical support for integrating science and literacy curriculum in early childhood English Language Learner classrooms.

 Science also offers a way for children to engage in early literacy skills through experimentation and documentation. Huerta and Jackson (2010) state inquiry-based science provides a plethora of tactile experiences that allow for vocabulary growth and allows for language to be used in the construction of scientific concepts. They further state the essentialness of providing students with a purpose for communicating through authentic experiences. They reiterate the necessity of providing English Language Learners with tools for writing during these authentic experiences, which allows the students to take risks with new language structures and vocabulary. Lee, Maerten-Rivera, Penfield, Leroy, and Secada (2008) further describe reasons science is effective for literacy and language development of English Language Learners in elementary school. They state:

 First, hands-on activities are less dependent on formal mastery of the language of instruction, thus reducing the linguistic burden on ELL students. Second, hands-on activities through collaborative inquiry support language acquisition in the context of authentic communication about science knowledge. Third, inquiry-based science promotes students’ communication of their understanding in a variety of formats, including written, oral, gestural, and graphic. Finally, by engaging in the multiple components of science inquiry, ELL students develop their English grammar and vocabulary as well as their familiarity with scientific genres of speaking and writing (p. 33).

In general, authors have demonstrated that an integrated science and literacy curriculum is a meaningful way for English Language Learners to develop science content and processes as well as literacy skills. They have also found that an integrated science and literacy curriculum enhances development of the English language.

Despite the demonstrated benefits of integrated curriculum with upper elementary school students, there is limited research on the effectiveness of integrated science and literacy curricula with young children. French (2004) studied the effects of an integrated science curriculum, ScienceStart!, used with students in Head Start preschool programs. The investigators administered the Peabody Picture Vocabulary Test at the beginning and end of the academic school year. The results from the standardized measures revealed substantial vocabulary gains for the preschool students. These results suggest that an integrated science and literacy curriculum would be effective at developing the vocabulary of young English Language Learners.

 Integrating science and literacy instruction was also found to be effective with students from diverse backgrounds in upper elementary school classrooms. For example, Lee, Deaktor, Hart, Cuevas, and Enders (2005) examined the effectiveness of an intervention involving the integration of science, English language and literacy, and the students’ home language and culture on third-, fourth-, and fifth-grade students. The results of their study revealed that, at the end of the academic year, the students made statistically significant gains on all measures of science and literacy achievement. Additionally, Morrow, Pressley, Smith, and Smith (1997) found similar results with third-grade students from diverse backgrounds. In their study, Morrow et al. (1997) created two experimental groups (literacy integration and science and literacy integration) and a control classroom. In the literacy integration group, classroom literacy centers, teacher-guided literature activities (such as retelling and rewriting stories), and independent reading/writing periods were components of classroom instruction. The science and literacy group received instruction similar to the literacy integration group but had several key differences: children’s literature that correlated to the third-grade science units were used to present science topics, and the students were asked to write stories that contained science facts. The results of this study showed classrooms in the science and literacy integration group scored significantly higher statistically on all literacy measures and all but one of the science measures used in this study. This study further supports the use of an integrated science and literacy curriculum for developing science and literacy abilities.

Overall, while much of the literature is concentrated on integrated curricula in upper elementary school classrooms, it does suggest an integrated science and literacy curriculum is an effective means of engaging young English Language Learners and developing their language, science, and literacy development. Therefore, helping educators integrate science and literacy curriculum will therefore allow them to allocate classroom time to science without sacrificing students’ language and literacy gains.

**Integrating Science and Literacy Curriculum**

The literature on methods for integrating science and literacy instruction for young children and English Language Learners is very limited. Majority of the literature on this topic relates to upper elementary and middle school students who presumably already have a basic level of mastery in literacy skills. However, this literature is important to explore as it has implications for methods that can be adapted for younger students. The literature is centered on two themes regarding integrating science and literacy curriculum: specific methods for integration and reciprocal learning processes. The literature on both themes is discussed so that later recommendations for young English Language Learners can be situated within the literature.

**Reciprocal Learning Processes**

 Authors have identified many processes that occur in science and literacy practices that are similar to one another. Understanding the reciprocal processes in science and literacy practices allows educators to gain a theoretical comprehension of ways in which integration between the two domains can occur. Douville, Pugalee, and Wallace (2003) draw connections between science and content literacy as well as informational literacy. They summarize that content literacy is connected with science through the need to engage in reading, interpreting, and creating visual representations such as graphs, charts, and diagrams. Douville et al. (2003) further explain that informational literacy is associated with science “through the construct strategies for locating information, accessing information, organizing and applying information and evaluating the information gathering process, as well as the final product” (p. 389). These processes, while reciprocal, are connected to specific types of literacy. Knowledge of these connections will be important for many learning situations; however, a broader understanding of parallels between science and literacy processes can provide even greater benefit to educators.

Casteel and Isom (1994) thoroughly explain the reciprocal processes that exist between literacy and science domains at a broad level. They have identified six processes that occur in literacy and science practice which, while not exactly the same, are parallel in nature. First, the process of asking questions in science is similar to the process of purpose setting that occurs before reading or writing. Secondly, hypothesizing closely parallels predicting because both processes require the use of background knowledge to anticipate future outcomes. Thirdly, science requires the process of gathering and organizing data, while literacy requires the organization of ideas. Fourth, students use the organized information or data for the similar process of analyzing results in science and composing in literacy. Fifth, the process of drawing conclusions in science is similar to evaluating or revising in literacy because students are required to look back on the work they have done and make judgments about its quality. Lastly, the science process of reporting closely resembles the process of comprehending/communicating in literacy because both skills require the summarization and dissemination of information. These similar processes are important for understanding how science and literacy curricula can be integrated in meaningful ways.

**Methods for Integrating Science and Literacy**

Literature on methods for integrating science and literacy curricula in lower elementary and early childhood classrooms is limited. The literature that does exist often focuses on thematic instruction or interdisciplinary instruction rather than focusing on integrating science and literacy as it has been defined here. However, it is important that this literature be discussed so that examples of different methods for integration can be seen and differences among the methods are more visible.

 Researchers have identified many strategies that teachers use when integrating science and literacy curriculum. For example, Douville et al. (2003) examined the ways in which upper elementary school teachers integrate science and literacy. Third-, fourth-, and fifth-grade teachers were surveyed and interviewed to determine their current practices for integrating math, science, and literacy curriculum. The curricular content that teachers used most often to integrate the curriculum was Earth science, solar system, weather, and animals. In third grade, literacy was integrated through the use of non-fiction/fiction texts and writing logs. In fourth grade students similarly used fiction and non-fiction books but also produced print products, reports, and writing journals. Some teachers also integrated the curriculum through vocabulary. Douville et al. (2003) also identified the strategies teachers used to create the curricula. They found the teachers were using research and supplemental materials (i.e. trade books), curriculum planning and instructional approaches, hands-on experiences, scientific method and science process skills, and use of writing (i.e. journaling). Overall, the researchers found that “teachers’ instruction had a potential to be *resource driven* rather than *conceptually driven*. That is, teachers may too often use science topics rather than developing macrostructual ideas that serve to connect the curriculum in ways that place instructional emphasis on concepts” (Douville et al., 2003, p. 394). These findings demonstrate that teachers make strong efforts to integrate science and literacy curricula, but the findings also reiterate the need for teachers to have a conceptual understanding of the parallel processes involved in science and literacy so that they may create integrated science and literacy curricula that is conceptually driven.

Additional authors have provided more specific examples of ways in which upper elementary school teachers integrate science and literacy curricula. Glynn and Muth (1994) outline some integrative practices used by teachers in upper elementary classrooms. These practices include reading trade books on science topics, biographies of scientists, newspaper stories, and science fiction stories. Additionally, the authors suggest integrating the curriculum by having the students write explanatory essays, field trip observation notes, laboratory logs, science journals, and environmental action letters. These strategies are focused on interdisciplinary instructional methods for integration because the central domain of focus is literacy with science content serving as a means to support the literacy goals.

Overall, many of the strategies discussed in the literature do not fully utilize the reciprocal processes that exist between science and literacy. Strategies that are based strongly on the aforementioned reciprocal processes can allow children to engage in science while simultaneously learning literacy processes.

**Recommendations for Educators of Young English Language Learners**

 The following recommendations for educators of young English Language Learners are meant to aid educators in creating curricula that allow students to engage in science practices while learning literacy skills. These recommendations draw from and build upon the literature for practices used with upper elementary students; however, there is a strong focus on making the connections to science and literacy processes apparent. Because a range of literacy skills in early childhood English Language Learner classrooms exists, educators will likely need to adapt these recommendations to fit the specific needs of their students. For consistency, examples of the recommendations provided are directed toward students who have begun to read and write using letter and sound relationships. Recommendations for integrating science and literacy curricula are provided below followed by a brief example of how the recommendation may look in a classroom.

**Aid Children in Researching**

Scientists and authors often begin their experimentation and writing processes by researching the topic of interest. Educators can use various forms of children’s literature to provide children with background knowledge on a topic as suggested by Casteel and Isom (1994). In order to achieve this with young English Language Learners, educators can engage the children in a shared reading experience. During this time, educators will be able to encourage children to practice the skills of predicting and evaluating their predictions in preparation for the science skills of making and testing hypotheses. Additionally, during this research time, educators could encourage children to ask questions about the topic of the story, which could then be used as the basis for later scientific experimentation.

**Provide Written Instructions for Experiments**

 As multiple authors have identified, allowing children to engage in scientific experimentation promotes meaningful language use and provides additional motivation for literacy learning (Huerta & Jackson, 2010; Lee et al., 2008). In order to support literacy development while still allowing children to engage in science processes, educators can construct simple experiment instructions for students to follow in order to complete the experiment. For example, educators can use sight words and small pictures of objects paired with text to make sentences that aid children in developing awareness that words are connected with specific objects or actions.

**Encourage Documentation**

First, educators can provide ways for students to document their hypotheses in writing. For example, if students were determining if objects sink or float in water, the educator could provide a pictorial list of the objects and invite students to write sink or float next to each picture. The educator could scaffold the students in developmentally spelling the words, yet the students are still engaged in the scientific process of hypothesizing.

Furthermore, as students engage in experimenting, educators should provide scaffolded ways for students to document what is occurring. Documentation can take on many forms and be adapted for different learning levels. For example, if students are conducting a car race to learn about friction, the students can write the color of the car that came in first, second, and third. Not only will documentation allow students to engage in meaningful early reading and writing activities, it allows them to engage in scientific processes.

**Analyze Results**

 Educators can aid children in reviewing their documentation to determine the results of the experiment. They can discuss factors that affected the results of the experiment and can even talk about any discrepancies that exist between data collected by different students (Casteel and Isom, 1994). Data from multiple students can be combined in the form of a chart or graph, which can help children see there are multiple ways to use symbols to represent real objects and events. Helping children take a critical stance on their data and experiments also develops the thought processes that are important for critical literacy—the idea that readers should analyze and question the texts they read. Using this recommendation will allow children to develop multiple forms of literacy and will develop their critical thinking.

**Disseminate Findings**

After scientists complete their experiments, they share the information they have discovered in written form. Teachers could help students experience this part of the science process by helping their students engage in disseminating their findings. One way that this could occur is through the practice of shared writing. Shared writing is a process in which teachers and students write a collaborative text based on a story or common experience, in this case, a science experiment. The teacher is responsible for asking questions that require students to focus on concepts of print, spelling, and reading for meaning (Gunning, 2004). This strategy will allow students to learn early writing processes while continuing to engage in a scientific process.

 Overall, the strategies listed here provide examples of ways in which educators can engage young English Language Learners in the process of doing science while creating opportunities for language and literacy development. By using these recommendations to create an integrated science and literacy curriculum, teachers will be able to devote classroom time to science thereby providing children with a more balanced education.

**Implications for Assessment**

 Assessing students is a critical component of educational practice. Adopting the above recommendations has several implications for the ways in which teachers can assess young English Language Learners. Specifically, integrating science and literacy curriculum provide more opportunities for authentic assessment, which is supported by multiple authors. For example, Bransford, Cocking, & Brown (2000) state “assessment that is consistent with principles of learning and understanding should: mirror good instruction, happen continuously, but not intrusively, as a part of instruction, [and] provide information…about the levels of understanding that students are reaching” (p.244). Wiggins and McTighe (2005) suggest a specific type of assessment that aligns with the Bransford et al. framework for assessment. They state “understanding is revealed in performance. Understanding is revealed as transferability of core ideas, knowledge, and skill, on challenging tasks in a variety of contexts. Thus, assessment for understanding must be grounded in authentic performance-based tasks” (Wiggins & McTighe, 2005, p.153). Performance assessment is especially relevant to the assessment of young English Language Learners since it allows educators to observe students’ understanding of science content and processes without a linguistics bias (Alvermann & Phelps, 2002). Therefore, by integrating science and literacy curricula, educators are able to include performance assessment among their repertoire of assessment practices, which will provide them with more information on their students’ understanding of science and literacy concepts.

**Discussion**

The recommendations listed above come with several limitations and directions for future research that are important to explore for the advancement of the field. The greatest limitation on the recommendations presented is that they are based on literature centered on methods for integrating science and literacy in upper elementary school classrooms. Because of this, it is possible that that adaptations made for classrooms with young English Language Learners may not be sufficient. There is a large gap in the literature on the topic of integrating science and literacy instruction with young children. In an age when educators are required to teach increasing amount of information and skills in one year, future research in this area is important for the advancement of the profession and the assurance that science remains included in curricula.

Overall, this paper provides a justification for integrating science and literacy curricula in classrooms of early childhood English Language Learners. While the literature on methods for curricular integration for early childhood classrooms is limited, strategies for methods of integrating science and literacy in classrooms of young English Language Learners were proposed. These recommendations will provide educators with a foundation for creating curricula that integrate the two domains so that science may again have a place in the classroom.

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