A Framework for Science Exploration: Examining Successes and Challenges for Preservice Teachers

by Keri-Anne Croce, Towson University

Abstract

Undergraduate preservice teachers examined the Science Texts Analysis Model during a university course. The Science Texts Analysis Model is designed to support teachers as they help students prepare to engage with the arguments in science texts. The preservice teachers received instruction during class time on campus before employing the model when teaching science to elementary and middle school students in Baltimore city. This article describes how the preservice teachers applied their knowledge of the Science Texts Analysis Model within this real world context. Preservice teachers' reactions to the methodology are examined in order to provide recommendations for future college courses.

Introduction

The National Science Teachers Association encourages science teachers to help students engage with science texts. Students have the potential to develop theories about the world by reading science texts. For example, within Next Generation Science Standards (2013) students are required to both create and understand arguments in science texts. Since the ways of communicating in science often differ from other disciplines (Miller & Czegan, 2016; Shanahan & Shanahan, 2012), teacher preparation programs must help teachers examine methodology that supports the analysis of science texts. Both the framework for K-12 science education (National Research Council, 2012) and the learning contexts that promote 21st century skills (Partnership for 21st Century Learning, 2007) suggest that students analyze scientific and technological information associated with their lives. This means that science educators must be familiar with models that support students' development of scientific thinking.

Science texts for children are often written by authors with a variety of expertise. Within elementary schools, students are often asked to engage with picture books and chapter books written by authors communicating the understandings of scientists. The scientists themselves rarely write these books. Within middle school, students engage with picture books, chapter books, and textbooks. Textbooks are often co-authored in conjunction with scientists. In order to meet the demand for education within STEM, teacher education programs must provide models that facilitate students' examination of science texts from a wide variety of authors. The Science Texts Analysis Model (Croce, 2017) provides structure for teachers so that they may facilitate a student's analysis of the arguments in a science text. The following article discusses how preservice teachers were encouraged to engage with the Science Texts Analysis Model as they examined science with elementary and middle school students in Baltimore city over a semester. This article discusses the instruction that preservice teachers received before, during, and after working with elementary and middle school students. The results of this study may influence how universities prepare teachers to help students develop as scientists.

The Science Texts Analysis Model

When students sit down to read science texts, it would be helpful if they were familiar with the ways that authors may structure their arguments. Social semiotics suggests that genres are the results of socially defined ways of communicating (Halliday & Hasan; Kress, 1993). While language is social and evolves, students must develop as scientists by beginning to understand patterns in communication. Research has discussed how to read diagrams and headings as well as look for the main ideas in science texts (Mawyer & Johnson, 2017; Coleman & McTigue, 2013; Coleman & Goldston, 2011), but the language in the main texts often contains patterns that remain unexplored in classrooms. Familiarity with the different ways that authors construct arguments may help students make meaning of science texts.

Science texts are always expanding in the ways that they use language; yet certain expectations are applied to science texts (Pappas, 2006; Kress, 1999). When sitting down to read a science textbook called 'Volcanoes' (Simon, 2006), you might not expect to encounter a discussion of the television shows that were set to premiere that night on prime time television. Instead, you would expect to be informed of that evening's television schedule by reading a T.V. guide. In the book about volcanoes, you would expect to read an explanation of the sequence of events that lead to volcanic eruptions. This is because of the social expectations that readers often have for science texts. For example, a science book sometimes contains language patterns that Halliday & Hasan (1985) call *'characteristic events.'* These are a series of events that, when linked together, create a phenomenon. Two different examples of characteristic events may be found in the first row of Table 1. The language that a student might find in an argument that includes a characteristic event might sometimes, but not always, include the terms 'first' or 'next' (Croce, 2014). Research has further broken down characteristic events into the potential for conditionality. *Conditionality* in science texts occurs when the existence of one event depends on the occurrence of another event (Croce, 2015). Examples of this may be seen in the second row of Table 1. The phrases 'If…then' and 'when' are used quite commonly in arguments supported by conditionality. A reader of a physics text might expect to see characteristic events and conditionality used to form arguments. The actual words and terms used in these sections may change over time, but the purposes of the sections remain. The language attempts to persuade by providing commonly occurring events (characteristic events) and the factors that determine the occurrence of these events (conditionality). Having these expectations for a physics text may help students begin to understand the text and react to it.

Table 1 (Click on image to enlarge)

Examples of Structural Elements in Science Texts

Textual element	*Purpose of the text*	*Examples from science texts*
Characteristic events (Hasan, 1985)	Author links sequence of events that commonly define a phenomenon.	"The first step in the birth of a tornado is usually a thunderstorm. This type of storm begins when warm, humid air rises upward from the ground." (unpaged, Simon, 1999) "Then the spider spins around and around in a spiral, working slowly out from the middle. Finally, it spirals back into the center and sits and waits for an insect to fly by." (p 28, Parsons, 1990)
Conditionality (Croce, 2015)	Author discusses how one event is only able to happen if another event has already happened	"When the wind is light, the sky is clear, and the air is damp, moisture in the air can often condense near the ground to form mist, or fog, especially at dawn or dusk. (p. 48, Cosgrove, 2004). "If a pollen grain from a flower lands on the pistil of the same kind of flower, it grows a long tube through the pistil into an ovule." (unpaged, Gibbons, 1991)
Descriptive attributes (Hasan, 1985)	Author discusses how elements are the same or different. The author discusses attributes of something.	"All caterpillars have tiny breathing holes. (p. 8, Green, 1986). "Some bugs hunt other bugs, not to eat themselves, but to feed to their babies." (p8. Dussling, 1998)

While a section in a physics textbook may contain a lot of characteristic events and conditionality, a textbook discussing classification might frequently contain descriptive attributes. Halliday & Hasan (1985) suggests that *descriptive attributes* provided attributes of a class. Examples of descriptive attribute may be seen on the third row of Table 1. Within these arguments, phrases such as 'often' and 'many' are frequently used. The language patterns suggest that a pattern of behavior is being discussed within a category of species. If students could predict how an author may structure the arguments in a section in a textbook discussing classification, they might form a framework for how to retell the text. If asked to create a summary of this science chapter, a middle school student may focus on the persuasive parts of the text that include descriptive attributes. This allows students to understand the text and formulate the language to talk about it. While science texts are not limited to the use of characteristic events, conditionality, and descriptive attributes, these language patterns can serve as an entry point that allow students to begin to understand how authors craft science texts.

Table 2 (Click on image to enlarge)

Science Texts Analysis Model (Croce, 2017)

Structural element of science text (Example: characteristic event, conditionality, descriptive attribute)	Example of structural element embedded in text	How did the elementary/middle school student interact with this structural element of the text?

Teachers may help students prepare to engage with the arguments in science texts by using the Science Texts Analysis Model (see Table 2). This model allows teachers to both analyze their own understandings of the ways that arguments are constructed in science texts (columns one and two) and begin to understand how students relate to these arguments in texts (column three). Within this model, teachers are not looking for students to replicate the language in the texts, but instead discuss how the author frames the arguments. As students make meaning of science texts by dissecting the arguments made by the authors, teachers may observe students' engagement with these arguments. Future instruction may be based on these observations.

Context

This article focuses on the experiences of undergraduate preservice teachers in a university course during one semester of a two-year teacher preparation program. The course addressed elementary and middle school students' use of a wide range of science texts such as picture books, chapter books, and textbooks. The university course took place both on the university campus as well as within a field placement in an elementary/middle school public school in Baltimore city. On Thursdays, preservice teachers attended class on campus in order to help them investigate and plan for their work on the following Wednesdays within the field placement. Each preservice teacher was assigned an elementary or middle school student. The preservice teacher was tasked with helping the student develop as a reader and writer of science, mathematics, and narrative. Each preservice teacher worked with one student for approximately 45 minutes each week in a Baltimore city school. While the preservice teachers were elementary school majors, they worked with both elementary and middle school students in the field placement. A key focus of the placement required preservice teachers to use science texts to help students develop as literate scientists. The elementary students worked with picture books and chapter books while the middle school students worked with textbooks in addition to picture books and chapter books. Within the placement school, elementary and middle school students were required to develop comprehension of science texts in order to take end of the year tests and meet state standards. In addition, two of the goals for the university course were to increase preservice teachers' understandings of science texts and to help preservice teachers develop a method for assessing and instructing elementary school students in science content (National Academies of Sciences, Engineering, and Medicine, 2017). The author of this article assumed both of the roles of instructor of the preservice teachers and researcher within the study. This article discusses how preservice teachers began to examine how authors use specific language patterns to develop arguments in science texts. The preservice teachers used these perceptions to help elementary and middle school students develop understandings of the arguments contained in science texts.

Participants

A total of nineteen undergraduate preservice teachers were enrolled in the course. These preservice teachers were enrolled in the first semester of the teacher program for elementary education teachers. The program was a screened major whose conditions for entrance included: receipt of successful scores on either PRAXIS or SAT exams, adherence to a GPA requirement, and completion of a set of course pre-requisites. The pre-requisites for the preservice teachers included completion of both a 100 level biology course and a 100 level physical science course.

Preservice Teachers' Employment of the Science Texts Analysis Model

The preservice teachers' engagement with the Science Texts Analysis Model was composed of three parts. First, they needed to analyze the language patterns that supported the authors' arguments in science texts. This required that preservice teachers examine both their own understandings of the genre of science texts as well as research in the field. Preservice teachers examined texts used with elementary and middle school students. The elementary school students used texts such as picture books and chapter books written by authors who interpreted the ideas of scientists. The middle school students used these texts as well as science textbooks co-authored by professional scientists and non-professional scientists. As preservice teachers began to develop general categories for language patterns that support arguments in science texts, they included these structural elements in column one of the Science Texts Analysis Model. For example, many students decided that a science text might contain a characteristic event. The term 'characteristic event' was placed in column one. Next, the preservice teachers needed to identify if different structural elements such as characteristic events were used in the texts that were selected for use with students in Baltimore city. If a preservice teacher determined that there was a characteristic event in the text, the preservice teacher then identified where it could be found in the text. This usually included placing in column two an exact quote from the text that demonstrated a characteristic event. This process was repeated for all the structural elements that had been placed in column one. Finally, preservice teachers needed to reconcile how the output from elementary and middle school students embodied the different arguments found in science texts. This information was collected in the third column of the model (Table 2). For example, did an elementary or middle school student engage with characteristic events in the text? If so, how? The preservice teachers were not looking for students to replicate the language of the text. Instead, a preservice teacher was observing if the student connected with this type of argument in the text. The preservice teacher then recorded in column three of the model the different ways that the student was connecting with this purpose for the text.

Preservice teachers prepared columns one and two of the model during classes held on campus at the university. After working with students in the field placement, the preservice teachers then brought their recorded observations of students to class on campus. They synthesized the information and placed students' responses to texts into column three of the model. The preservice teachers had the opportunity to gather each week on campus with their classmates and discuss in small groups how to apply students' responses to column three of the model. Completing all the columns in the Science Texts Analysis Model allowed preservice teachers to plan further instruction with the elementary and middle school students for the following week. By engaging in this process, the preservice teachers helped elementary and middle school students meet multiple science standards such as evaluating multiple sources of information in order to address a problem or assessing the premise of a text (Next Generation Science Standards, 2013).

Preservice teachers were introduced to the Science Texts Analysis Model in multiple ways. First, the professor pre-assessed students' knowledge and demonstrated the model in class. Second, preservice teachers were directed to explore the model in class over a variety of contexts. Third, a reading was assigned to encourage preservice teachers to examine the research that supports the model. Fourth, preservice teachers were asked to prepare for their work in the field placement by completing columns one and two of the model. Fifth, preservice teachers employed the model when working with elementary school students in the placement and collected data from the students. Sixth, the preservice teacher returned to class on campus with the data that they had collected. Both classmates and the professor helped the preservice teachers begin to understand how to analyze the data and apply it to the third column of the Science Texts Analysis Model. Finally, once preservice teachers completed the model, they were encouraged to plan further instruction with the elementary and middle school students by completing a graphic organizer. The discussion below details this entire process.

Description of Participant Experiences

Weeks One through Four

The professor began the introduction of the Science Texts Analysis Model by pre-assessing the preservice teachers' ideas related to the construction of science texts. During pre-assessments, preservice teachers were asked to brainstorm their own understandings of the meaning of a variety of science texts. Preservice teachers initially responded with statements that lacked detail such as, "This book is about volcanoes." At this time, the preservice teachers were unable to discuss how the author used language patterns to structure arguments in the texts.

The instructor built on preservice teachers' understandings by demonstrating possible ways to use the Science Texts Analysis Model. Preservice teachers were asked to think about how authors structured arguments in science texts. The instructor modeled for the class the possible ways that language patterns supported arguments in different ways in science texts. An example of this modeling can be found in Table 1. Preservice teachers were then asked to analyze the arguments in science texts. After this analysis occurred, preservice teachers participated in both small group and whole group discussions.

In order to allow further examination of the Science Texts Analysis Model, preservice teachers were also given multiple science texts published in countries outside of the United States. Distributed science texts published in Spain, Italy, Japan and France were written in languages other than English. The preservice teachers did not speak the languages contained in these texts but were able to use picture cues to attempt to understand how an argument was structured. For example, Arnold (2013) published a text out of Paris that contained two pages of pictures that illustrate the inner workings of a motor. These pictures allowed the author to structure an argument that implied a sequence of events that are typically found in the running of a motor. This demonstrated that pictures can be used in addition to words in order to formulate the arguments in texts. Preservice teachers were then asked to complete the first and second columns of the Science Texts Analysis Model and share their developing understandings in both small and whole group discussions. The goal of these interactions was to allow preservice teachers to explore how students from multiple linguistic backgrounds might approach science texts.

Preservice teachers were asked to read a research chapter outside of class in order to support their developing understandings of the Science Texts Analysis Model. After completing the reading assignment at home, preservice teachers were asked to create reading reflections. This allowed preservice teachers to use research to support their developing understandings of the Science Texts Analysis Model. Groups of preservice teachers met during class time to discuss their reflections.

Week Five

After examining the Science Texts Analysis Model in class at the university, preservice teachers were asked to prepare for use of the model in the field placement. They each selected a science text to use with an elementary or middle school student the following week. During this time, a class library was introduced to assist preservice teachers in selecting a science text to use with students in the public schools. The preservice teachers were encouraged to select texts that both converged and diverged with students' prior knowledge. This would allow the elementary and middle school students to experience a wide range of science texts from multiple authors. Preservice teachers discussed their text selections with myself and each other. Independently the preservice teachers completed column one and two of the model using the selected texts. Groups then gave each preservice teacher feedback on columns one and two of the Science Texts Analysis Model.

Table 3 (Click on image to enlarge)

Example of a Preservice Teacher's Engagement with the Science Texts Analysis Model Before the Field Placement

Structural element of science text	Example of structural element embedded in text	How did the elementary/middle school student interact with this structural element of the text?
Characteristic events	Moisture evaporates from the water into the atmosphere.	
Descriptive Attribute	The eye of a hurricane is fairly calm.	

Table 3 shows how one preservice teacher interacted with the Science Texts Analysis Model during interactions in class prior to working with a student at the placement. This example demonstrates how preservice teachers developed understandings of arguments presented in science texts.

Weeks Six through Twelve

Preservice teachers brought the preselected texts and Science Texts Analysis Models to use in the field placements. They were encouraged to allow their work in column one and two of the model to influence their work with the elementary and middle school students. Preservice teachers observed the responses of the elementary and middle schools students while working with the science texts. Preservice teachers then returned to class at the university campus and synthesized elementary and middle school students' responses in order to complete the third column of the Science Texts Analysis Model. Table 4 presents an example of a preservice teacher's use of the Science Texts Analysis Model after working with a student in the field placement.

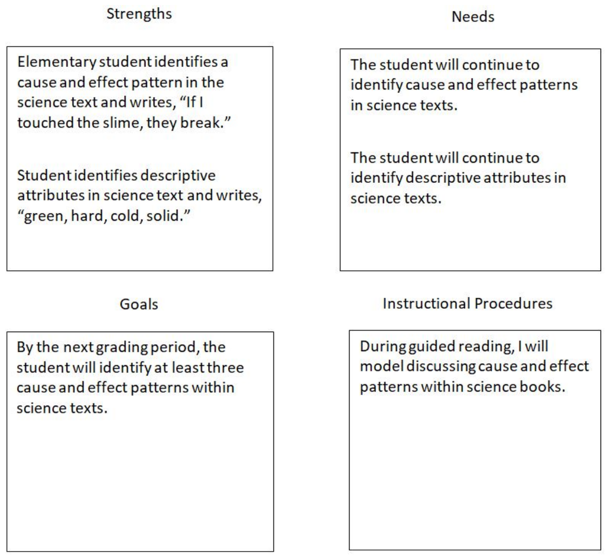
Table 4 (Click on image to enlarge)

Example of a Preservice Teacher's Engagement with the Science Texts Analysis Model After the Field Placement

Structural element of science text	Example of structural element embedded in text	How did the elementary student interact with this structural element?
Conditionality	When you slap the slime, the cornstarch doesn't have time to move. (Shores, 2010, p. 20)	After reading the science text, the elementary student wrote, "When she storm the spoon, the slime did not move because they stay in the container."

Preservice teachers were encouraged to use the new understandings developed from the Science Texts Analysis Model to determine elementary and middle school students' strengths and needs. This allowed the preservice teachers to plan further instruction with the elementary and middle school students. Planning organizers, called 'Strengths/needs/goals/ instruction procedure organizers' (SNGI organizers) (Croce, 2017) were provided to preservice teachers in order to allow them to determine elementary students' strengths and needs in analyzing science content. This information allowed preservice teachers to then set goals and plan instructional procedures. Figure 1 presents an example as to how a preservice teacher used information from the Science Texts Analysis Model to plan instruction and assessment in a SNGI organizer.

Figure 1 (Click on image to enlarge). A preservice teacher's strengths/needs/goals/ instruction procedure organizer (SNGI organizer) (Croce, 2017).



Preservice teachers were encouraged to repeat all of the parts of the Science Texts Analysis Model over subsequent weeks using multiple science texts with elementary and middle school students. Information from the model was used to plan instruction within the Strengths/needs/goals/ instruction procedure organizers (SNGI organizers) presented in Figure 1. Small group discussions in class on campus provided preservice teachers with support.

Data Sources and Data Analysis

Collection of five data sources occurred throughout the study. Observational notes were taken during weeks one through twelve of the study in both the university class and at the field placement. At the end of week four, preservice teachers were given a survey before they entered the field placement. During weeks five through twelve, the author collected preservice teachers' completed Science Texts Analysis Models and 'Strengths/needs/goals/ instruction procedure organizers (see Table 4 and Figure 1). Finally, preservice teachers were given another survey at the end of the study in week twelve.

The first survey was given to preservice teachers after four weeks and before they worked with elementary and middle school students in the field placement. They were asked to withhold their names from the surveys. The survey asked preservice teachers to produce written responses to the following questions:

- Describe how you feel as you prepare to engage your elementary/middle school student with a science text. For example, do you feel that you have expectations as to how a student might engage with a science text? Do you have a sense as to how you might respond to your student as they engage with the science text?
- Do you have recommendations for how the model may be modified?
- Do you have any recommendations for how to modify the instructional procedures that were used to help you understand this model?

The second survey was given at the end of the semester after the preservice teachers worked with the elementary and middle school students in the field placement. Again, preservice teachers were asked not to attach their names to the surveys. The survey asked preservice teachers to produce written responses to the following questions:

- Describe how you feel after you have worked with your elementary/middle school student. Do you feel that you are able to take the students' responses and determine how they are developing science literacy?
- Do you have any recommendations for modifying the model?
- Do you have any recommendations for how to modify the instructional procedures that were used to help you understand this model?

What follows is a discussion of the preservice teachers' analysis of their experiences as well as observed actions and dialogue on campus and at the placement at the public school.

Reflections on Instruction and Assessment of Science Texts Analysis Model

Before preservice teachers entered the field placement, the instructor noticed a few areas where the preservice teachers may need to interact with the Science Texts Analysis Model in different ways in order to ensure success. Observational notes taken during class time revealed that preservice teachers might initially struggle to understand the arguments presented by a science text. For example, during class time on campus, a preservice teacher was asked to read a text about hurricanes. When challenged to describe what the text was about she indicated, "It was a bunch of facts about hurricanes." The instructor needed to prompt the preservice teacher to examine the science text as a written scientific argument. The Science Texts Analysis Model suggests that authors use specific language patterns in order to construct different scientific arguments. Structural elements such as characteristic events, descriptive attributes, or conditionality may support the discussions in science texts. For example, an author may need to distinguish a pattern of events by using conditionality to support an argument. This can be seen in this section of a science text written by Cosgrove (2004), "If the water is warm enough (over 80 F/27 C), several storms may cluster together and whirl around as one, encouraged by strong winds high in the atmosphere." (p. 44-45). After the instructor discussed the use of conditionality in this part of the text, the preservice teacher commented, "I never thought about a science text as the sum of different structural elements. I always viewed a science text as one fully crafted idea. I now get that there are different elements that go into making a science argument." This exchange demonstrates that some of the preservice teachers entering the teacher preparation program had not yet begun to examine the construction of arguments in science texts. In addition, preservice teachers may not have examined their own roles as readers and writers of science texts prior to entering the program. Classroom observations confirm that many preservice teachers initially viewed their roles as passive receptacles of information, as opposed to individuals who critically analyzes scientific arguments. This demonstrates that classroom instruction needs to allow time for individuals to evolve in their understandings of their roles as developing scientists and readers of science texts.

Preservice Teachers' Feedback after Four Weeks

Based on data collected during the first survey collection, nineteen out of nineteen preservice teachers reported that they felt supported as they prepared to help engage students with different structures within an author's argument in a science text. This feedback arrived just before the preservice teachers were set to begin working with elementary and middle school students. One preservice teacher indicated on the survey:

> I feel comfortable with science texts, as I know what structural elements are important and how to identify them in text.

Some preservice teachers indicated that employing the Science Texts Analysis Model aided them in determining questions to use support their elementary and middle school students' critical thinking about the arguments in science texts. For example, on the survey one preservice teacher described a level of comfort before teaching the placement student:

> I will ask questions to prompt my student to think about the different aspects of science texts. What did it look like? What does it do? Is that different from something else?

Preservice Teachers' Feedback after Twelve Weeks

After working with the elementary and middle school students, nineteen out of nineteen preservice teachers felt confident that they could analyze the responses of their elementary and middle school students. One respondent stated on the survey:

> I feel that the student understands science literacy because of her written responses to the questions I asked. She found compare and contrast, descriptive attributes, and cause and effect patterns in the texts.

Feedback from the surveys suggests that more time might be spent with preservice teachers discussing how to solicit feedback from elementary and middle school students. For example, a preservice teacher wrote on the survey:

> Should we ask direct questions to prompt them to recall certain parts of the text? I would go over this in more detail.

This feedback suggests that class instruction for preservice teachers might include more debate as to the value of open-ended retelling of a text versus asking students to respond to question prompts. There are differing theories as to whether students should be encouraged to respond to the open-ended question, "What was that about?" versus asking students to respond to more directed questions such as “What arguments did the author make?” and “How did the author structure her arguments? What language patterns did she use?” Preservice teachers may benefit from a class discussion dissecting both approaches.

Recommended Modifications

Instructors may consider engaging preservice teachers in discussion as to how the Scientific Texts Analysis Model may engage students who speak, read, and write languages other than English at home. Preservice teachers may need to understand what it looks like and feels like to engage with a science text in a language that is not used at home. As was previously mentioned, during one class period at the university I brought in science texts written by authors from a variety of countries in a variety of languages. Preservice teachers were asked to examine the texts independently and in small groups. While preservice teachers were not able to understand the written languages in the text, they were able to begin to understand the picture cues that authors use to provide context to support scientific arguments. After experiencing these texts, preservice teachers indicated that they better understood how English language learners might use picture cues to understand science arguments. One preservice teacher wrote:

> I think the model of science texts from other countries to put us into the student’s perspective was helpful because I could see what structural elements were more difficult to find in just pictures or diagrams.

This preservice teacher discusses his/her/their own experiences interacting with a text in a language that is unfamiliar. The preservice teacher is noting that students who are new to experiencing English may need more support if a textual element is not represented in a picture or diagram. Many preservice teachers realized that when working with English language learners, science texts might be selected that provide illustrations that support some of the arguments in the text. An example within the data that supports this statement may be seen here:

> I liked the use of the science books in different languages to help us understand what it might feel like to our students and how to evaluate picture cues.

This preservice teacher suggests that it was important to experience what it may feel like to examine a text in a language not spoken at home. An instructor may also consider reading a science text aloud in class in a language not used in the preservice teachers’ homes. This may allow preservice teachers to attempt to begin to brainstorm the types of teaching methods that may support multilingual learners. Within the study, preservice teachers were encouraged to use wordless picture books such as Wiesner’s (2006) text ‘Flotsam’ to support developing learners of English at the placement. The wordless picture books provide illustrations that allowed students to focus on the processes being described in the texts without struggling to understand the written English. Use of wordless picture books allowed elementary and middle school students to exhibit the next generation standard of engaging in argument from evidence and constructing explanations using the text (Next Generation Science Standards, 2013).

After observing preservice teachers working with developing learners of English, I would also encourage the use of science graphic novels and cartoons as genres for science explorations. These may include texts such as Wicks' (2016) 'Science comics: Coral reefs: Cities of the ocean.' Many science graphic novels and science comics use less complex syntax that allows developing learners of English to connect to the authors' arguments. Many texts include strong persuasive arguments that are supported through the elaborate illustrations.

Preservice teachers began to observe that it is appropriate to use assessment tools beyond the verbal when assessing English language learners' understandings of arguments in texts. They also began to notice that elementary and middle school students might respond to science texts through a variety of mediums. At least 15 students noted this either on their surveys or during discussions in class at the university. For example, one preservice teacher wrote:

> I feel good about working with my student on science texts. I created a rubric and was able to mark off certain things that they responded to based on what I felt were important attributes of the text. I counted verbal and physical responses.

Analysis of the preservice teacher's Strengths/needs/goals/ instruction procedure organizers (SNGI organizers) revealed that they were beginning to examine how the model might incorporate non-verbal information such as hand motions, drawings, and movement of models and manipulatives. By the end of the twelve weeks, seventeen out of nineteen preservice teachers included nonverbal actions in their SNGI organizers. For example, an elementary student may use hand motions to demonstrate storms coming together to form a hurricane. It is suggested that observation of students' actions, such as hand motions, be recorded in column three in the model. Non-verbal actions can demonstrate a student's understandings of a structural element and should be included in the model. This will allow students to communicate their understandings in multiple ways.

Conclusions and Implications

This article began by presenting two goals for the undergraduate course. The course sought to increase preservice teachers' understandings of science texts and to help preservice teachers develop a method for assessing and instructing elementary and middle school students in science content. The results of the study suggest that preservice teachers felt supported as they engaged with the Science Texts Analysis Model before and after a field placement. Analysis of the data revealed that preservice teachers were able to apply this new knowledge to the 'Strengths/needs/goals/ instruction procedure organizer (SNGI organizer). As a result, it is recommend that future university coursework allow preservice teachers to apply the Science Texts Analysis Model in a teaching placement after receive instruction in a classroom setting. Application of the model allows preservice teachers to use their newfound understandings in a real world context.

It is recommended that preservice teachers be encouraged to consider how the Science Texts Analysis Model may be used with students from a variety of linguistic backgrounds. This will allow preservice teachers to begin to understand the variety of ways that multilingual students respond to science texts. The preservice teachers in this study began to explore how to evaluate non-verbal responses during discussions with elementary and middle schools students. In addition, it is suggested that multiple genres, such as wordless picture books and science graphic novels, may support the development of elementary and middle school students as scientists. This article suggests ways that future instructors might assist students in examining how authors of science texts craft scientific arguments. After engaging in this type of instruction, teachers may be better prepared to help students understand and communicate scientific findings. This will allow students to examine science in the world.

References

Arnold, N. (2013). *Comment ca marche? Moteurs et voitures*. Paris: Gallimard Jeunesse

Croce, K. (2014). Assessment of Burmese refugee students' meaning making of scientific informational texts. *Journal of Early Childhood Literacy, 14*, 389-424.

Croce, K. (2015). Latino(a) and Burmese elementary school students reading scientific informational texts: The interrelationship of the language of the texts, students' talk, and conceptual change theory. *Linguistics and Education, 29*, 94-106.

Croce, K. (2017). *Navigating assessment with linguistically diverse learners.* Charlotte: Information Age Publishing

Colman, J. & Goldston, J. (2011). What do you see? *Science and Children, 49*(1), 42-47.

Colman, J. & McTigue, E. (2013). Methods & Strategies: Unlocking the power of visual communication. *Science and Children, 50*(5), 73-77.

Cosgrove, B. (2004). *Weather*. New York: DK Publishing.

Dusling, J. (1998). *Bugs! Bugs! Bugs!* New York: DK Publishing

Fang, Z. & Coatom, S. (2013). Disciplinary literacy: What you want to know about it. *Journal of Adolescent & Adult literacy, 56*, 627-632.

Gibbons, G. (1991). *From seed to plant*. New York: Holiday House.

Green, R. (1986). *Caterpillars*. New York: Mondo publishing

Halliday, M.A.K. & Hasan, R. (1985). *Language, context, and text: Aspects of language in a social semiotic perspective*. New York: Oxford University Press

Kress, G. (1999). Genre and the changing contexts for English language arts. *Language Arts, 76*, 461-469.

Mawyer and Johnson (2017). Read like a scientist. *The Science Teacher, 84*(10). 43-48.

Miller, D. & Czegan, D. (2016). Integrating the liberal arts and chemistry: A series of general chemistry assignments to develop science literacy. *Journal of Chemical Education, 93*, 864-869.

National Academies of Sciences, Engineering, and Medicine. (2017). *Seeing students learn science: Integrating assessment and instruction in the classroom.* Washington, DC: The National Academies Press.

National Research Council. (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas. Committee on a conceptual framework for new K–12. Science education standards. Board on science education, Division of behavioral and social sciences and education.* Washington, DC: The National Academies Press.

Next Generation Science Standards (2013). *Connections to the Common Core Standards for literacy in science and technical subjects.* http://static.nsta.org/ngss/AppendixM-ConnectionsToTheCCSSForLiteracy-6.12.13.pdf

Shanahan, T. & Shanahan, C. (2012). What is disciplinary literacy and why does it matter? *Topics in Language Disorders, 32*(1), 7-18.

Shore, L. (2010). *How to make slime*. Mankato: MN, Capstone Press.

Simon, S. (1999).*Tornadoes*. New York: HarperCollins Publishing.

Simon, S. (2006). *Volcanoes*. New York: HarperCollins Publishing.

Parsons, A. (1990). *Amazing Spiders*. Dorling Kindersley: London.

Partnership for 21st Century Learning. (2007). *Framework for 21st Century Learning*. http://www.p21.org/our-work/p21-framework

Wicks, M. (2016). *Science Comics: Coral Reefs: Cities of the Ocean*. New York: First Second.

Wiesner, D. (2006). *Flotsam*. New York: Clarion Books