Pre-service Elementary Science Teacher Preparation through Children’s Literature: The Very Hungry Caterpillar as a Test Case

David C. Owens, Gillian E. McCall, Kimi Jaikaran, Nedra Cossa, Thomas R. Koballa Jr.

Abstract

We investigated pre-service elementary teachers’ engagement in science and English language arts (ELA) instruction integrated in the context of a children’s book. Teachers developed models and conducted a compare-and-contrast analysis after exposure to different accounts of the butterfly life cycle: a popular children’s book, The Very Hungry Caterpillar, and a scientific account from National Geographic called “Butterfly: A Life.” The mixed-methods research was guided by the following question: What are the affordances and limitations of children’s literature toward engineering an understanding of the butterfly life cycle for pre-service elementary teachers? Content analysis indicated that pre-service elementary teachers’ abilities to compare and contrast the two accounts were not exceptional, as they failed to discriminate between ideas offered in the accounts and missed details of the key aspect of the butterfly life-cycle phenomenon: metamorphosis. However, the quality of participants’ butterfly life-cycle models significantly increased after exposure to the scientific account. We suggest the potential for an additional ELA standard, asking and answering such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text, as a means for enhancing compare-and-contrast skills following these activities.

Key Words: butterfly life cycle; caterpillar; children’s literature; English language arts; integration; modeling.

Introduction

The reluctance of elementary teachers to facilitate science instruction in their classrooms is a well-documented, international phenomenon that is poised to get worse (Banilower et al., 2013; Mullis et al., 2016). Historically, a lack of science content knowledge and the low confidence to teach science that results have been credited for elementary teachers’ reluctance to do so (Pengestigast et al., 2017). More recently, elementary teachers have been increasingly hard-pressed to focus instructional time on mathematics and literacy to meet the rigor of standardized testing for those subjects (Blank, 2012). Doing so often means sacrificing time that might have been spent on other subjects, such as the sciences, social studies, and art, which are not the focus of standardized testing at the elementary level (Dillon, 2006). Without a substantial intervention, any hope that this issue will be resolved is likely misplaced.

A promising strategy for aiding pre-service elementary teachers in overcoming science content knowledge and teaching confidence deficits is to integrate science into English language arts (ELA) instruction through children’s literature. Integrating science through children’s literature also provides opportunities for modeling instruction that prepares pre-service teachers to overcome time constraints in their future classrooms. For example, utilizing children’s literature with which pre-service elementary teachers are already familiar might provide a less threatening environment for learning science, especially for teachers whose experience with science in their own schooling was poor (Edwards & Loveridge, 2011). Additionally, children’s books are known for their propensity to espouse science misconceptions that pre-service elementary teachers could look to tease out using a critical lens of science (Trundle & Troland, 2005; Sackes et al., 2009).

In their classrooms, elementary teachers can use one children’s story as a context for addressing multiple disciplines, such as science and ELA, which could optimize their use of class time. Equally important, doing so could also lead to students’ engagement in higher-level thinking that crosses disciplinary boundaries, such as considering different accounts of a phenomenon through fictional and scientific sources (McLean et al., 2015). Moreover, teachers often teach in the manner they learned as students – so modeling high-quality science instruction that also addresses tested subjects, such as ELA, during their undergraduate teacher preparation has great potential for providing hope that science instruction in elementary classrooms will become more commonplace in the future (Pringle, 2006).

In this study, we sought to better understand how undergraduate pre-service elementary teachers engage in integrated science and ELA instruction to meet standards they will be responsible for teaching in the near future. Specifically, pre-service teachers were tasked with developing and revising butterfly life-cycle models, as well as conducting a compare-and-contrast analysis regarding aspects of two accounts of the butterfly life cycle: a popular work children’s literature first published in 1969, The Very Hungry Caterpillar.
Caterpillar (hereafter “VHC”, Carle, 1994), and a scientific account from National Geographic called “Butterfly: A Life” (hereafter “NG”; National Geographic, 2010). Additionally, participants were asked to elaborate on two aspects of the accounts that researchers found to be different: the diet of the caterpillar during the larval stage and the means by which metamorphosis occurred (pupal stage).

Here, we provide the results of a content analysis of pre-service elementary teachers’ thinking and offer means for using the findings to inform undergraduate pre-service preparation for teaching and learning science in the context of ELA and science standards. Our research was guided by the following question:

What are the affordances and limitations of children’s literature (i.e., The Very Hungry Caterpillar) toward engendering an understanding of the butterfly life cycle for pre-service elementary teachers?

Modeling & Butterfly Life Cycles

Given our investigation’s focus on pre-service teachers’ butterfly life cycle explanations – and on the science practice of modeling, in particular – it is important to highlight what is meant by modeling and its importance to the teaching and learning of science. Models serve as simplified representations of natural phenomena, such as the butterfly life cycle, for use in explanation and prediction (Zangori et al., 2017). “Modeling” as a science practice refers to the construction of an initial model to account for a particular phenomenon, the use of the model to explain or predict the phenomenon, the evaluation of the model’s ability to account for the phenomenon, and the revision of the model to increase its explanatory power when additional evidence becomes available (Schwarz et al., 2009). It is important to differentiate between scientific consensus models that have resulted from numerous iterations of the modeling process – to which teachers may refer as a didactic instructional aide – and the modeling process for the purposes of teaching and learning (Acher et al., 2007). In the latter case, learners use models “to represent their current understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate ideas to others” (National Research Council, 2012, p. 57). Most teachers’ experiences with modeling or model-centered inquiry are limited, and when teachers do employ models, it is often in reference to scientific consensus models when teaching content, rather than using modeling as a means for enhancing students’ reasoning about phenomena or their understanding of the nature of science (van Driel & Verloop, 1999; Windschitl & Thompson, 2006; Acher et al., 2007). In this study, we explore pre-service elementary teachers’ engagement in modeling practice in which modeling cycles are informed by information from two sources – children’s literature (VHC) and a scientific account (NG) – regarding butterfly life cycles, a topic that has proven difficult for students and pre-service elementary teachers alike (Cinici, 2013; Kim, 2014).

Methods

Research Context

Participants were undergraduates enrolled in one of two semesters of an integrated life/earth science course for pre-service elementary teachers with 14 and 11 participants (N = 25). The class met two days a week for 1.25 hours each meeting. The stated purpose of the course was to enhance life and earth science content knowledge and practices while modeling pedagogically appropriate instruction defined by interactive activities and cooperative learning in a supportive learning environment, the sum of which would be expected to contribute to the pre-service elementary teachers’ confidence in teaching science (Guziec & Lawson, 2004). Given that elementary teachers often face pressure to focus instructional time toward content areas that are subjected to standards-based tests (e.g., ELA) and away from science, the course focused on the use of children’s literature that addressed science topics to simultaneously serve as a single context for teaching both science and ELA. The investigation described herein took place two-thirds of the way through the semester. At that point, students had spent the first half of the semester engaged in science practices in the context of astronomy. The second half of the semester delved into life science, which began with study of the characteristics of living things. This led up to the study of life cycles described below.

Description of Instruction

This study is focused on pre-service elementary teachers’ abilities to model the butterfly life cycle, as well as to compare and contrast the two accounts of the butterfly life cycle, one fictitious (VHC) and the other scientific (NG). These two accounts were selected for their potential to provide meaningful contexts for addressing the Next Generation Science Standards and the Common Core English Language Arts Standards:

- 3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.
- CCSS ELA-LITERACY.RL.2.9. Compare and contrast two or more versions of the same story by different authors or from different cultures.
- CCSS ELA-LITERACY.RL.2.6. Identify the main purpose of a text, including what the author wants to answer, explain, or describe.

Specifically, VHC and NG are two versions of the same story of the butterfly life cycle, one fictitious and the other a scientific account. This allowed for compare-and-contrast, as well as consideration of the different purposes of the two texts, as called for by the two ELA standards referenced. Additionally, given that VHC is a popular yet simple account that differs in a number of ways from the more detailed and empirically sound NG account regarding important aspects of the butterfly life cycle (e.g., diet, timing, metamorphosis), these two accounts were expected to aid participants in meeting the referenced life science standard while engaging in the iterative process of modeling that was expected to uncover misconceptions that have been observed among both student and pre-service elementary teacher populations when considering the butterfly life cycle (Cinici, 2013; Kim, 2014).

It is worth noting that this last ELA standard (2.6) aligns well with its scientific corollary regarding understandings of the nature of science deemed important for elementary students (for grades 3–5, see NGSS Lead States, 2013, p. 6) – whereas authors may write children’s literature that addresses science phenomena, such as the caterpillar life cycle, with any number of purposes in mind (e.g., foster imagination, teach a moral lesson) and without being held to account by any factual constraints (Kamm, 1971; Epstein, 1986), science texts account for the mechanisms of natural phenomena by way of explanations that are limited to those that can be supported with empirical evidence.
The butterfly life-cycle instruction that guided the research was adapted from National Geographic (2020). The activity is described below. For a diagram of the flow of butterfly life-cycle instruction and data collection, see Figure 1.

**Steps of the Lesson**

1. A definition of life cycle was projected on the overhead: “A life cycle is a series of changes that happens to all living things” (Britannica Kids, 2020).

2. Participants (four per table) were tasked with considering human life cycles and discerning the life stages that should be included. Beginning the consideration of life cycles with a species that participants were familiar with was expected to facilitate their identification of the life stages that traditionally define life cycles.

3. The instructor collected the responses on the whiteboard and informed the participants of those stages emphasized in the Next Generation Science Standards (NGSS) third-grade standard, which served as the focus of the day's instruction (3-LS1-1: Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death; for alignment of the materials, lessons, and activities in this article with NGSS, see the Appendix).

4. Participants were asked to consider aspects of life that differently characterize the life stages of humans. A list of characteristics was compiled (e.g., dependence or independence, length of time in stage, food eaten during stage, development).

5. Participants were provided a generic human life-cycle model that included the following stages: in utero, birth, growth, reproduction, and death. They were tasked with detailing the characteristics that differently described each of the life stages of the human life cycle on their models.

6. After the students shared their models with their peers, the instructor provided his model of the human life cycle with characteristic descriptions of each life stage (Figure 2), which could also serve as a guide for subsequent modeling of the butterfly life cycle.

7. Students were introduced to an adapted version of the instructional modeling sequence (Schwarz et al., 2009; Introduce anchoring phenomenon; construct a model; use the model; evaluate the model; revise the model).

8. Once students had practice considering life cycles from a familiar perspective (humans), they were introduced to a potentially novel phenomenon: the butterfly life cycle. Students were read VHC and asked to develop a model of the butterfly life cycle, using the model of the human life cycle as an example/format. The instructor played a two-minute video of Eric Carle, the author of the book, reading VHC and showing the pictures. The video was looped during students’ development of their model (Puffin Books, 2020).

9. Once the students completed their model, they were shown the two-minute NG video (National Geographic, 2010). Then students were asked to compare and contrast the two accounts of the butterfly life cycle (i.e., similarities and differences; see items 1 and 2 below).

10. Students were then asked to create a new model of the butterfly life cycle, taking into account the new information they have. The NG video of the caterpillar life cycle is run on a loop during students’ development of the model.

11. Finally, students were tasked with responding to three prompts (items 3–5), including how cocoons and chrysalis differ and what a caterpillar eats as it emerges from the egg (see items 3 & 4 below) as well as how and why writers of children’s storybooks might change ideas from a scientific account.

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**Figure 1.** Flow of butterfly life-cycle instruction and data collection.

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**Figure 2.** Instructor’s shared model of the human life cycle, including life stages and their characteristics.
Data Collection

Open-Ended Response Questions

Participants responded to five open-ended questions. The first four referred to the content of the two accounts, including similarities and differences between the two accounts in general, as well as specific questions regarding diet and metamorphosis. The final question regarded participants’ perspectives about why the two accounts might differ, based on author purpose.

- **Item 1:** Compare and contrast the account of the butterfly life cycle provided by NG with the account in VHC. How are they similar?
- **Item 2:** Compare and contrast the account of the butterfly life cycle provided by NG with the account in VHC. How are they different?
- **Item 3:** What do all caterpillars eat as they emerge from the egg and fatten up to become a butterfly?
- **Item 4:** When thinking about a caterpillar’s life cycle, how does a cocoon, as was described in VHC, and a chrysalis, as was seen in NG, differ?
- **Item 5:** Write a brief paragraph that answers the following: How do storybooks, such as VHC, change the ideas? Why would a writer do this?

Participants’ responses to these five items, as well as the pre- and post-NG butterfly life-cycle models participants developed, served as the data collected for analysis.

Data Analysis

We employed a mixed-methods approach to better understand the affordances of children’s literature (i.e., VHC) toward engendering an understanding of the butterfly life cycle for pre-service elementary teachers. All data were subject to content analysis, which enabled researchers to make inferences “by objectively and systematically identifying specified characteristics of messages” (Holsti, 1969, p. 14) found in participants’ responses to the open-ended items and in their models of the butterfly life cycles. The qualitative codes that resulted were then converted into numerical codes through a quantization (Miles & Huberman, 1994; Tashakkori & Teddlie, 1998). Codes associated with the open-ended items were converted into frequency counts to indicate the percentage of participants’ responses in which each code appeared. Codes associated with the models were quantified so that participants’ initial models could be compared with the models they developed after observing the scientific account of the butterfly life cycle. Data were analyzed in three phases:

1. The researchers transcribed the National Geographic video and inductively analyzed the content of both accounts (i.e., VHC and NG) to provide a starting point from which to consider the similarities and differences that might appear in the participants’ responses and whether those they identified were accurate. To accomplish this, the researchers read VHC and independently engaged in emergent open coding by noting each instance of occurrence and its characterization in chronological order before coming together and reaching a consensus as to the codes that emerged. The same strategy was employed for the NG account. Then the coded instances of occurrence, as well as their characterizations, were compared and contrasted across the two accounts to build tables of similarities and differences (Tables 1A and 1B). Researchers then used these inductive codes that emerged from their content analysis of the two butterfly life-cycle accounts as a priori codes for the content analysis of participants’ responses to the first four items.

2. The researchers analyzed participants’ responses to each of the four items. The a priori codes developed above guided the analysis of the first four items, though researchers were open to additional codes that might emerge from participants’ responses, as their responses included information that may or may not have accurately represented the information in the two accounts. The researchers enhanced their understanding of the accuracy of responses regarding the butterfly life cycle by referring to scientific texts (e.g., Jabr, 2012). Three researchers first independently coded the first 10 participants’ pre- and post-responses to each of the four items, noting aspects of each response that got at the root of the question being asked, including misconceptions. Then the researchers compared the codes that appeared through their independent analyses and reached consensus on the codes associated with each response. Finally, the researchers used the same strategy to code the remaining 15 participants’ responses. Once the analysis was completed, the researchers conducted a frequency count for each code that emerged in the responses to each item and identified exemplar quotes to represent each. The frequency with which each code appeared in participants’ responses, as well as accompanying exemplar quotes, can be found below as tables regarding each open-ended item.

3. Participants’ pre- and post-NG butterfly life-cycle models were analyzed for the presence/absence of the three main categories of information that were provided by the VHC and NG accounts: time, diet, and growth regarding each of the four life stages (egg, larva, pupa, and adult). A fourth category, misconceptions, was included for each

| Table 1A. Similarities between The Very Hungry Caterpillar and the National Geographic account. |
|---------------------------------|---------------------------------|
| **Instance of Occurrence**      | **Characterization**            |
| Start of story                  | With an egg                     |
| Habitat                         | Egg laid on leaf, story happens there |
| Emergence: Caterpillar          | Caterpillar emerges from egg    |
| Diet                            | Caterpillar eats a lot after emergence |
| Growth                          | Caterpillar gains size/mass by eating |
| Time of metamorphosis           | Two weeks                       |
| Emergence: Butterfly            | Butterfly emerges from cocoon   |
| Story line                      | The life cycle of a caterpillar from egg to butterfly |
of the four life stages to account for inaccuracies that appeared in participants’ models. To better understand how participants’ butterfly life-cycle models may have changed after having encountered the scientific account (i.e., NG), a point was assigned for participants’ accurate inclusion of each of the three types of information (i.e., time, diet, and growth) for each of the four life stages in their models, for a total possible score of 16 points for a particular model. One point was subtracted from participants’ scores for any misconception they may have included in each of the four life stages of the model for four possible lost points (see Table 7). Analysis of variance (with “semester of student enrollment” included as a fixed factor) was used to indicate significant differences between participants’ butterfly life-cycle models before and after participants’ exposure to the scientific (NG) account.

### Results

The results are organized as follows. First, findings from analysis of the four open-ended items are reported. Then findings from analysis of the models are reported.

#### Open-Ended Items

1. **How well did participants compare the two accounts?**

Participants accurately and inaccurately noted similarities between the VHC and NG accounts. Accuracies in participants’ noted similarities. Participants accurately identified a number of similarities between the two accounts, including the general story line (e.g., the life of a caterpillar), the diet/feeding of the caterpillar, the growth of the caterpillar, that the caterpillar started as an egg, the two-week duration of metamorphosis, the habitat in which the action took place (i.e., on a leaf), the emergence of the butterfly, the emergence of the caterpillar, and the independence of a caterpillar (i.e., no parental rearing). For frequency of and exemplars for each of these accurate themes, see Table 2A.

**Table 1B. Differences between The Very Hungry Caterpillar (VHC) and the National Geographic (NG) account.**

| Instance of Occurrence | Characterization |
|------------------------|------------------|
| NG provides backstory  | e.g., month of egg laying, differentiation between new and previous generation of butterflies (i.e., differential life spans [10×], marathon of travel to Mexico) |
| Emergence mechanism (larvae) | VHC: sunny pop NG: nibbles way out |
| Diet | VHC: all kinds of food and a leaf NG: egg casing and leaf (milkweed) |
| Diet reasoning | NG: Massive consumption of food would aid marathon migration |
| Diet–time | VHC: 1 week; NG: 2 weeks |
| Caterpillar personification | VHC: stomach ache; hunger |
| Metamorphosis | VHC: builds cocoon house around himself NG: anchored by silk, the caterpillar dissolves into a rich fluid; then its cells sprout anew, giving rise to wings, legs, antennae |
| Emergence mechanism (butterfly) | VHC: nibbles hole in cocoon NG: casing splits along seam |
| NG more detailed | Number of eggs Habitat and food are milkweed Time for larvae to emerge from egg (4 days) Time spent eating (2 weeks) Time for wing prep after butterfly emerges (a few hours) Growth of caterpillar quantified (2000×) |

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**Table 2A. Aspects that participants accurately identified as similarities between the two accounts, including their frequency of appearance in participants’ responses (N = 25 participants), the code assigned to account for the similarity, and a quote that best exemplified the similarity for each.**

| Item 1: Compare and contrast the account of the butterfly life cycle provided by National Geographic with the account in The Very Hungry Caterpillar. How are they similar? | % | Similarity between the Two Accounts | Exemplar |
|---|---|---|---|
| 56 | The diet/feeding of the caterpillar | “the constant eating of the caterpillar” |
| 56 | The growth of the caterpillar | “how much they have grown” |
| 40 | The general story line (e.g., life of a caterpillar) | “both were about the life of a caterpillar” |
| 40 | The caterpillar starts as an egg | “starts as an egg” |
| 28 | The two-week duration of metamorphosis | “after two weeks it becomes a butterfly” |
| 16 | The habitat in which the action took place (e.g., on a leaf) | “egg on a leaf” |
| 16 | The emergence of the butterfly | “both talk about the butterfly coming out” |
| 8 | The emergence of the caterpillar | “larva must emerge” |
| 8 | The independence of the caterpillar (i.e., no parental rearing) | “both showed how butterflies are not really dependent on their mother just food and themselves” |
Table 2B. Aspects that participants inaccurately identified as similarities between the two accounts, including their frequency of appearance in participants’ responses (N = 25 participants), the code assigned to account for the similarity, and a quote that best exemplified the similarity for each.

| %  | Similarity between the Two Accounts | Exemplar |
|----|-----------------------------------|----------|
| 56 | The metamorphosis of the caterpillar (e.g., includes a cocoon) | “both talk about building a cocoon” |
| 20 | The timing of events (e.g., duration of feeding) | “two weeks of eating” |
| 8  | The specificity of caterpillar growth (e.g., 2000x birth size) | “body mass 2000x what it was a birth” |
| 4  | The caterpillar starts as an egg | “full grown butterflies lay eggs” |
| 4  | The habitat in which the action took place was milkweed | “eggs are laid on milkweed” |
| 4  | The caterpillar is growing to prepare for migration | “get bigger for their migration” |

Inaccuracies in participants’ noted similarities. Participants inaccurately indicated that the accounts were similar regarding aspects of the metamorphosis (e.g., building a cocoon – there was no cocoon in NG), the timing of events (e.g., the duration of feeding differed between accounts), the specificity of caterpillar growth (i.e., 2000x birth size; VHC did not quantify growth), that full-grown butterflies lay eggs (no egg laying occurred in VHC), that the habitat in which the action took place was milkweed (VHC did not specify the type of plant the caterpillar was on), and that the caterpillar was growing to prepare for migration (the idea of migration did not appear in VHC). For frequency of and exemplars for each of these inaccurate themes, see Table 2B.

(2) How well did participants contrast the two accounts?

General differences. Participants identified a number of general differences between the two accounts. For example, participants indicated that the diet of the caterpillar, the amount of detail provided, the length of time the caterpillar gorged, the stage of life at which the story began, and aspects of the metamorphosis differed between the two stories. For frequency and exemplars for each of these accurate themes, see Table 3A.

Detail differences. Participants also noted a number of specific details that were provided in NG but were absent in VHC. For example, NG provided more detail regarding timelines, number of eggs laid, life span, reasoning as to why the caterpillar was gorging on food, metamorphosis, egg laying, location, gender, vocabulary, and the butterfly’s selection of habitat for egg laying. For frequency and exemplars for each of these accurate themes, see Table 3B. It

Table 3A. Aspects that participants identified as differences between the two accounts, including their frequency of appearance in participants’ responses (N = 25 participants), the code assigned to account for the difference, and a quote that best exemplified the difference for each.

| %  | How Do The Very Hungry Caterpillar and National Geographic differ? | Exemplar |
|----|---------------------------------------------------------------|----------|
| 56 | The diet of the caterpillar | “Actually eats leaves and plants, not junk food” |
| 28 | The amount of detail provided | “N.G. gave more detail on everything” |
| 24 | The length of time the caterpillar gorges | “Carle- 1 week eating/ caterpillar/growth NatGeo- 2 weeks eating/ caterpillar/growth” |
| 12 | The stage of life cycle at which the story begins | “Starts with butterfly laying eggs” |
| 8  | The metamorphosis process | “Wraps itself in silk for 2 weeks” |
| 4  | The inclusion of migration in backstory | “Mentions migration of the butterflies” |
| 4  | The factual nature of the account | “The book does not give factual evidence of the life of a butterfly” |

Table 3B. Specific details that participants identified as differences between the two accounts, including their frequency of appearance in participants’ responses (N = 25 participants), the code assigned to account for the difference, and a quote that best exemplified the similarity for each.

Item 2: Compare and contrast the account of the butterfly life cycle provided by National Geographic with the account in The Very Hungry Caterpillar. How are they different?

| %  | Detail | Exemplar |
|----|--------|----------|
| 60 | Timelines | “National Geographic video went into detail about time in each stage” |
| 28 | Number of eggs laid | “National begins by talking about the butterfly laying up to 200 eggs” |
| 28 | Life span | “live 10x longer than parents” |
| 16 | Reason that caterpillar gorged on food | “explains why it eats, why it needs to (migration / build up nutrients)” |
is worth noting that only three of the 25 participants noted the difference in metamorphosis between the two accounts, and only one participant noted the backstory provided in NG regarding the migration. No students noted that personification was employed in VHC, unlike in NG.

(3) How did participants perceive the diet of the caterpillar?

The bulk of participants indicated that caterpillars eat leaves, and about half noted that the caterpillar consumed the egg casing from which it emerged. One-fifth of students indicated that the caterpillar consumed milkweed, specifically. A few left it at “plants” (Table 4). One student inaccurately indicated that caterpillars eat “their cocoon.” Interestingly, one student reported that caterpillars eat pollen and nectar from flowers, which is not accurate, but butterflies are known to feast on these items, though that information was not shared in either VHC or NG.

Table 4. Aspects that participants identified as what caterpillars eat after they emerge from the egg, including their frequency of appearance in participants’ responses (N = 25 participants), the code assigned to account for the similarity, and a quote that best exemplified the similarity for each. An asterisk is used to identify inaccurate responses.

| % | What Do Caterpillars Eat after Emerging from the Egg? | Exemplar |
|---|------------------------------------------------------|-----------|
| 64 | Leaves                                               | “They feed on leaves and fatten up to become a butterfly” |
| 44 | Egg casing                                            | “They eat their egg casing when they come out of the egg” |
| 20 | Milkweed                                             | “Milkweed, the plant they tend to be born on. This plant serves as food” |
| 16 | Plants/vegetation                                    | “Most caterpillars eat plants and mostly have a green/plant based diet” |
| 4  | *Pollen and nectar from flowers                      | “Pollen and nectar from flowers” |
| 4  | *Their cocoon                                        | “their cocoon” |

(4) Did participants perceive the cocoon and chrysalis differently?

It was clear that participants did not pick up on the differences in metamorphosis between the two accounts. In fact, none of the participants’ responses included an accurate difference between the cocoon and the chrysalis. Instead, participants either did not state a difference, made inaccurate statements, or stated a difference that was not accurate (Table 5). One might question whether it is even important whether it is a cocoon or chrysalis. Here, the ELA standard holds learners to account for being able to compare and

Table 5. The frequency in participants’ responses regarding the difference between a cocoon and a chrysalis, the code assigned to account for the response, and a quote that best exemplified each.

| % | Type of Difference Stated | Exemplar |
|---|---------------------------|-----------|
| 56 | No difference was stated regarding the cocoon and chrysalis | “A chrysalis is formed around the caterpillar, then fluid breaks down caterpillar and then the legs and wings are formed + caterpillar becomes a butterfly.” |
| 44 | An inaccurate statement was made regarding the cocoon and chrysalis | “The national geographic provided more details like the chrysalis was made of silk spun and the caterpillar wrapped itself into it.” |
| 28 | An inaccurate difference was stated regarding the cocoon and chrysalis | “A cocoon is what the caterpillar first creates around itself and moves into. Over time as the caterpillar develops more into a butterfly inside, it eventually becomes a chrysalis.” |
contrast – the ELA standard acts as reinforcement for students who might question the value of that piece of knowledge.

(5) Why would the VHC writer change the ideas?

More than half of participants indicated that authors of children’s literature, such as Carle’s of VHC, simplify the science in the stories they tell to make science concepts easier for children to understand (Table 6). Just under half indicated that authors change the science ideas to make the story more interesting, relatable, or funny to children.

| Item 5: Write a brief paragraph that answers the following: How do storybooks, such as The Very Hungry Caterpillar, change the ideas? Why would a writer do this? |
|---|
| % | Changed Ideas May Positively Affect Learning Outcomes | Exemplar |
|---|---|---|
| 56 | Simplify the science to make it easier to understand | “It breaks down the process in more simplistic terms for young children to follow and comprehend.” |
| 48 | Change ideas to make the story more interesting, relatable, or funny to children | “The Very Hungry Caterpillar makes the story of a caterpillar’s life cycle much more interesting for a child to read. The writer changed the ideas so viewers could get a more entertaining, child-friendly version of a caterpillar’s life cycle.” |

Table 6. Aspects that participants identified as to how authors change ideas for children’s books and the reason for doing so.

Participants’ scores (mean ± SE) on their life-cycle models significantly increased (Figure 3) from before (3.18 ± 0.37) to after (6.87 ± 0.64) exposure to the scientific NG account (p < 0.001; Cohen’s d = 0.25). Participants’ model scores ranged from 0 to 7 prior to the scientific (NG) account and from 1 to 12 after exposure to it. Table 7 shows the points that participants earned/lost. See Figure 4 for a butterfly life-cycle model exemplar. Interestingly, six of the 25 participants did not connect the adult in their post-intervention butterfly life-cycle models with the egg to indicate the continuation of life and, hence, the cycle.

| Butterfly Life-Cycle Models |
|---|
| Participants’ scores (mean ± SE) on their life-cycle models significantly increased (Figure 3) from before (3.18 ± 0.37) to after (6.87 ± 0.64) exposure to the scientific NG account (p < 0.001; Cohen’s d = 0.25). Participants’ model scores ranged from 0 to 7 prior to the scientific (NG) account and from 1 to 12 after exposure to it. Table 7 shows the points that participants earned/lost. See Figure 4 for a butterfly life-cycle model exemplar. Interestingly, six of the 25 participants did not connect the adult in their post-intervention butterfly life-cycle models with the egg to indicate the continuation of life and, hence, the cycle. |

| Conclusions |
|---|
| Our results suggest that children’s literature, such as VHC, can serve as a viable context for integrating science and ELA instruction, though a better understanding of science phenomena, such as the butterfly life cycle, can be afforded when accompanied by a scientific text. Specifically, pre-service elementary teachers’ abilities to compare and contrast the two accounts were not |

Table 7. Number of participants (N = 25) who earned (or lost, in the case of misconceptions) a point for each category (i.e., time, diet, growth) of each of the four life stages on their initial and post-NG butterfly life-cycle models.

| Model | Egg | Larva | Pupa | Adult |
|---|---|---|---|---|
| | T | D | G | M | T | D | G | M | T | D | G | M | T | D | G | M |
| Initial | 1 | 2 | 0 | 0 | 11 | 22 | 18 | –8 | 14 | 2 | 2 | –16 | 0 | 0 | 0 | 0 |
| Post-NG | 20 | 1 | 0 | 0 | 14 | 47 | 32 | –2 | 13 | 1 | 20 | –14 | 13 | 0 | 0 | 0 |

Note: T = time, D = diet, G = growth, M = misconception, NG = National Geographic.
exceptional, as they failed to discriminate between ideas offered in the accounts and missed details of the key aspect of the butterfly life-cycle phenomenon: metamorphosis. However, the quality of participants’ butterfly life-cycle models significantly increased after exposure to the scientific account. Along those same lines, elementary teachers who use children’s literature, such as The Very Hungry Caterpillar, to teach ELA without also including a corollary scientific account (e.g., the National Geographic account) may fail to provide their students opportunities to identify and remedy misconceptions they have regarding the phenomenon under study and could even reinforce misconceptions promulgated by children’s literature. We suggest that educators who are integrating science and ELA instruction in the context of children’s literature might look to enhance their students’ abilities to compare and contrast by following up these activities with a focus on each stage of the butterfly life cycle in the two accounts through the lens of an additional ELA standard: Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text (CCSS.ELA-LITERACY.RL.2.1).

Implications

Elementary classrooms are important incubators of curiosity – a place where an affinity for a lifetime of science learning can be engendered. In an era when science instruction in elementary classrooms is conspicuously minimized, integrating science into ELA instruction is one means for increasing its inclusion in elementary curricula. This study builds on a growing body of literature that evidences the potential for children’s books to serve as inroads for the development of elementary educators’ own science teaching and learning self-efficacy while providing a road map for overcoming obstacles to increasing the quality and quantity of science instruction in elementary classrooms.

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Appendix

**Connections to NGSS**

The chart below makes one set of connections between the instruction outlined in this article and the NGSS. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities. The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectation listed below.

| Performance Expectation | Connections to Classroom Activity |
|-------------------------|----------------------------------|
| 3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. | Students develop models of the butterfly life cycle after reading the *very hungry caterpillar* and revise their models after considering the National Geographic account of the butterfly life cycle. |

**Science and Engineering Practice**

| Develop models to describe phenomena. (3-LS1-1) |

**Disciplinary Core Idea**

| LS1.B: Growth and Development of Organisms Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (3-LS1-1) |

**Crosscutting Concept**

| Patterns of change can be used to make predictions. (3-LS1-1) Nature of Science. 3-5 Science explanations describe the mechanisms for natural events. |

Connections to the *Common Core State Standards* (NGAC & CCSSO 2010)

**English Language Arts**

- CCSS.ELA-LITERACY.RL.2.9. Compare and contrast two or more versions of the same story by different authors or from different cultures.
- CCSS.ELA-LITERACY.RL.2.6 Identify the main purpose of a text, including what the author wants to answer, explain, or describe.