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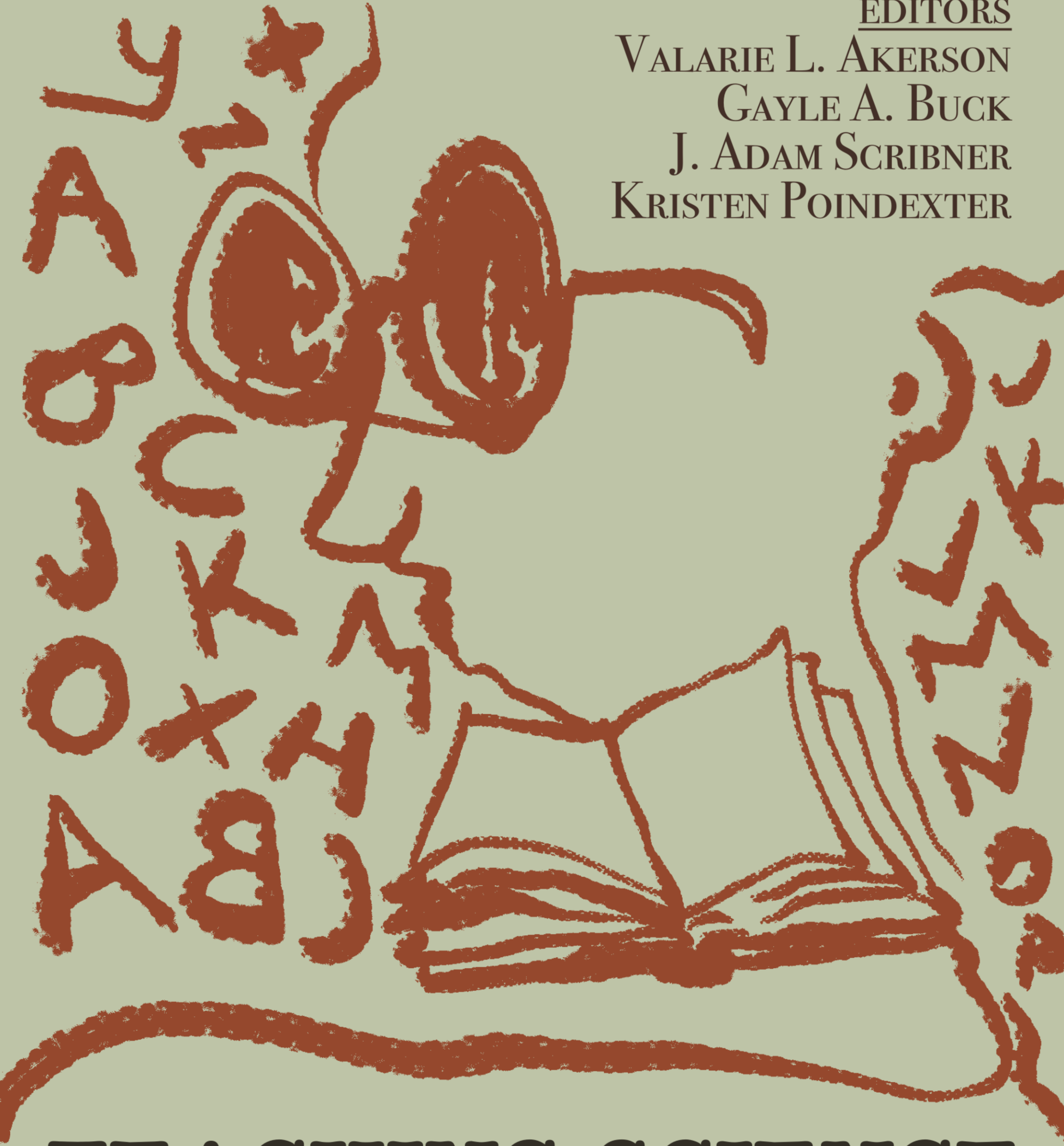

TEACHING SCIENCE

with reading strategies

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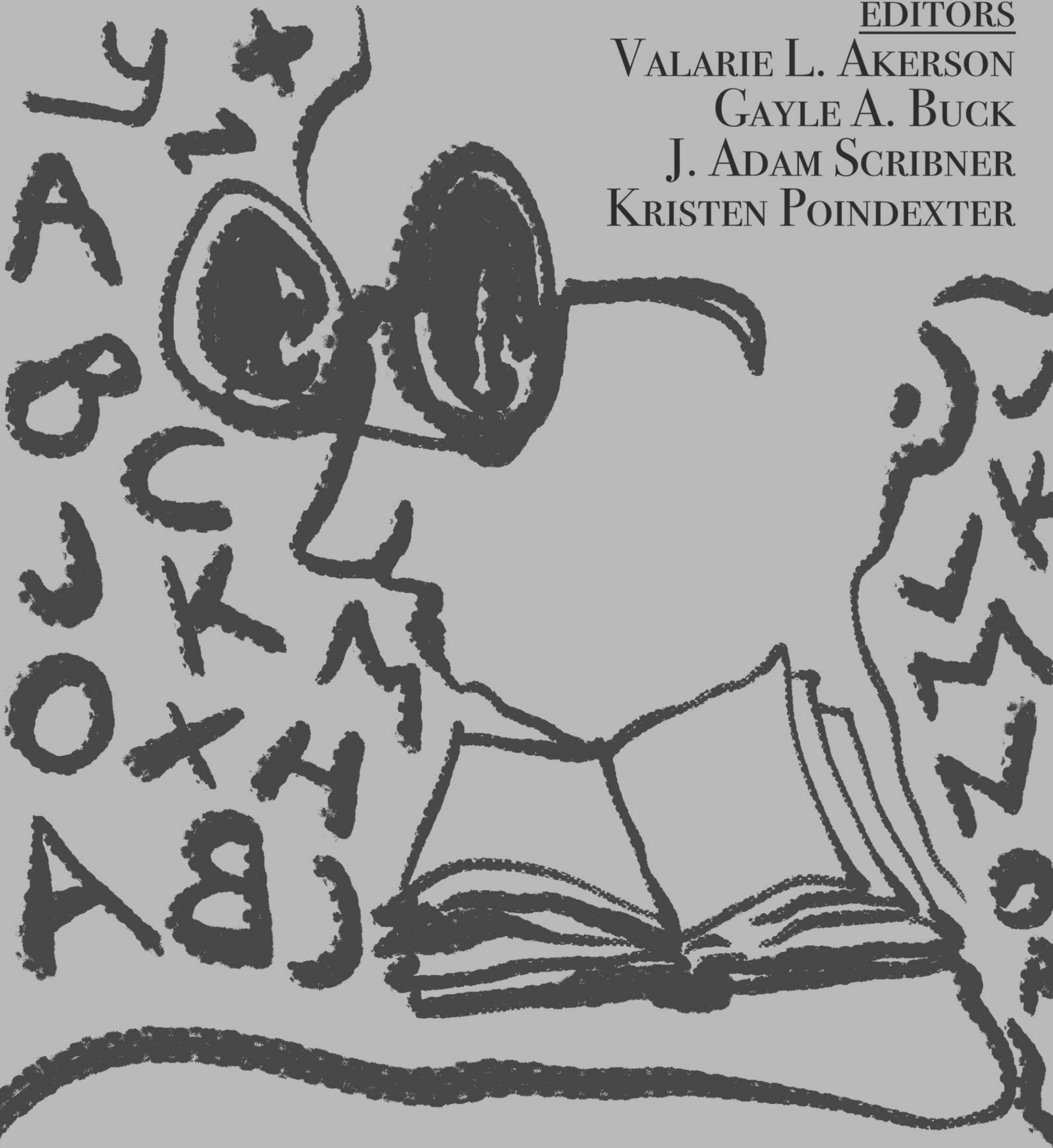

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iSTES

Teaching Science with Reading Strategies

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Table of Contents

INTRODUCTION

Chapter 1 - Teaching Science with Reading Strategies

Valarie L. Akerson , Gayle A. Buck

Chapter Highlights

- This chapter provides a rationale for why we focus on teaching science through reading
- The chapter focuses on the types of reading strategies that are targeted through science in this book
- The chapter foreshadows the contents of the book and describes the structure

Introduction

Many elementary teachers enjoy teaching language arts and literacy, and who would argue the importance of those skills for elementary students? Certainly it is essential for all to develop language literacy to not only communicate, but to navigate through the world throughout their lives. But indeed, equally important is the development of functional scientific literacy, for global citizens to be able to make important health and personal decisions based on science rather than other ways of knowing, not to mention the importance of scientist education beginning at the youngest ages.

So how can we address the problem of not only helping our students develop language literacy, but also scientific literacy? We recommend interdisciplinary science and literacy instruction. We define this as such "We emphasize maintain the distinct differences between science and language arts, while combining instruction in one discipline to support learning in the other" (Akerson, 2008). As science educators, we know that these subjects complement each other and, if done correctly, greatly support each other, and promote learning across disciplinary standards.

In this book we work with several of our best elementary science teachers and science teacher educators to demonstrate to their peers nationwide how we can use science instruction to promote literacy development, and vice versa. This book emphasizes evidence-based innovations - each chapter describes an action research study on an innovation aimed at helping the teacher teach a science topic using one or more 'science of reading' strategies. In this way, our innovations are tested out with the students for which they are intended. The science of reading is a suite of evidence-based understandings of reading acquisition and instruction. It includes methods and approaches that research has shown to give kids and learning advantage in reading (Shanahan, 2019). These reading strategies include: 1) Phonemic Awareness, 2) Phonics, 3) Fluency, 4) Vocabulary, and 5) Comprehension.

Phonemic awareness is where listeners can hear, identify, and manipulate phonemes, which are the smallest mental units of sound that contribute to meaning. Phonics refers to sound-letter correspondence, decoding of written words, synthesizing understandings from text, and morphology, or the study of structure and content of word forms. Fluency indicates the continuity, smoothness, rate, and effort in speech production, generally when reading text.

Vocabulary is the set of words that is known to the individual, in terms of reading and spoken language. Finally, comprehension refers to the ability to understand the meaning of the written text. So based on the decoding the words and putting together into sentences, it is also understanding the meaning of the paragraph or the reading overall.

Others have found that science and language arts combine quite well, such as Akerson and Young (2005) who point out ways for nonfiction writing activities to not only teach science concepts, but to also teach reading strategies. Wheeler-Toppen (2011) agrees, noting that writing skills are real world requirements for all students, including science students, and that incorporating writing and science can improve students' strengths in both, and understandings of both.

Indeed, some states now have Science of Reading, and require particular focus on particular strategies for teaching reading, and various resources exist for determining those strategies and also for incorporating other content (such as science) into those strategies (e.g. Jiban, 2022; Sedita, 2024). Jiban (2022) focuses on helping teachers to help students become fluent readers and build comprehension. Sedita (2024) focuses on developing writing strategies to build content knowledge of various concepts (such as science). In our experience, combining literacy instruction with science instruction can support the learning of both content areas, when done effectively (Akerson, 2008; Douglas, et al 2006). In this volume we provide evidence-based resources for teachers of all levels to use literacy strategies to support science learning, and vice versa.

Why Action Research?

Action research enables us to engage in an authentic evidence-based teaching experiences at various teaching levels, Pk-16. Action research enables us to test our strategies and strive to improve our teaching, and therefore, our students' learning (Sagor, 2000). Action research strives to solve problems of practice. In our case, our problem of practice is to use science to support learning of reading strategies.

Clark, et al (2020) note that action research is a cyclical process, where the teacher collects data on the teaching and student learning, and then reflects on and modifies the teaching. It is a cycle of observing, reflecting, and acting, and results in informed decision-making and change. Teachers of various levels and various contexts have designed action research studies to determine best practices in using reading strategies to support sience learning, and to use science as an impetus to develop language learing. In this book we use action research to illustrate problems and solutions for incorporating science instruction into reading instruction. We use action research to show the kinds of evidence-based teaching that can be used in classrooms at various levels.

Structure of the Book

The purpose of this book is to explore incorporation of science instruction into teaching reading strategies through action research. As such, we have several sections that we are including (1) Incorporating Science into Reading Strategies in the Elementary Grades, (2) Incorporating Science into Reading Strategies in Preservice Teacher Science Methods Courses, and (3) Incorporating Science into Reading Strategies into In-service Teacher Workshps and Institutes. Prior to these sections we include a literature review of research on previous strategies used to incorporate science and reading into instruction. Below we share an overview of the book sections:

Section 1 - Elementary Science Teaching

We have two chapters in this section, both set in Kindergarten classrooms where the reader can see how literacy skills can be developed from the youngest students through science. In Ms King's chapter adult volunteers and students used reading as well as scientific inquiry strategies to explore and learn more about penguins. In Dr. Poindexter's chapter children' s literature is highlighted as ways to improve science literacy with young students, as well as their language development.

Section 2 - Preservice Science Methods Courses

We have three chapters in this section. In the first chapter by Dr. Poindexter explored how to prepare preservice elementary teachers to use reading strategies to support science knowledge development. The preservice teachers experienced the reading strategy inspired science lessons as models for what they could do in their future classrooms. In the Bartels and Boche chapter they shared how to be intentional and explicit in making science integrated with reading strategies. They recommend the use of reading strategies to aid in development of scientific literacy and emphasizing the strategies more than once to ensure that the preservice teachers will be able to conceptualize and use the ideas and strategies in their own classrooms. In the Markavage et al chapter the lead instructor explored how to use children's literatüre to aid elementary preservice teachers to incorporate literacy into science instruction. They hoped to make children's literatüre an important component of instruction, not simply a "hook" to get students interested in science.

Section 3 - Inservice Teacher Workshops and Institutes

We have two chapters in this section that explores helping inservice teachers to use reading strategies to teach science. First, Scribner shares about using storytelling strategies to develop science knowledge and practical strategies for teaching these to students in an environmental workshop. In the Buck et al, study the focus was on supporting inservice teachers who focus on helping students use medial communication through gamification. Explicit insights are provided for incorporating game-based approaches in elementary and middle school levels.

Conclusion and Recommendations

As we can see from this variety of action research studies in elementary classrooms and with preservice and inservice teachers, reading strategies can be used to support science instruction. Indeed, science content knowledge can improve, and reading strategies can be used to support science learning. For elementary and middle school teachers, reading strategies can be a pathway to improving science learning through incorporating children's literature, game-based projects, modeling for teachers, incorporating story telling, and various explicit strategies that not only support science learning, but also development of language and language literacy skills. Supporting scientific literacy through language literacy can be done, and the chapters in this volume provide guideposts for how to create such interactive and interdisciplinary lessons to support student learning.

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LITERATURE REVIEW

Chapter 2 - Integrating Literacy Skills into K–12 Science Education

Nicole D'Andrea

Chapter Highlights

- *Literacy is essential for science learning:* Reading, writing, speaking, and listening are integral to engaging in scientific inquiry, understanding complex concepts, and developing critical thinking skills at all grade levels.
- *Effective integration requires explicit strategies:* Teachers must use structured approaches like PACT, vocabulary instruction, and discipline-specific reading strategies to support student comprehension and participation in scientific discourse.
- *High-quality texts and phenomena-based instruction deepen engagement:* Diverse, content-rich materials that reflect real-world science and student identities foster deeper understanding and inclusive classroom environments.
- *Collaborative learning and discourse enhance scientific reasoning:* Structured student talk, peer interaction, and dialogic activities support language development, content mastery, and equitable access to science.
- *Systemic support is necessary for success:* Schools must provide professional development, dedicated planning time, and access to aligned instructional resources to help teachers implement integrated science and literacy instruction effectively.

Introduction

The integration of literacy into science education has emerged as an essential practice for enhancing student comprehension, engagement, and equity across K–12 classrooms. Rather than viewing literacy and science as separate disciplines, current research advocates for a cohesive instructional approach where reading, writing, vocabulary development, and discourse are interwoven into science instruction to promote scientific literacy. As students enter middle school, reading comprehension challenges can hinder their ability to learn in content specific classes, particularly for students with disabilities and multilingual learners. To address this, general and special education teachers can implement effective strategies for literacy throughout instructional approaches in science education, which embed evidence-based literacy practices into content instruction and provide all students with the tools needed to succeed in both literacy and science learning (Shelton, 2020). This integration is not only beneficial for student achievement but is increasingly necessary given the linguistic diversity of modern classrooms and the demands of evolving educational standards.

Literacy in science education refers to the ability to read, write, and engage in discourse specific to scientific contexts. This includes comprehending complex scientific texts, articulating scientific concepts, and using language as a tool for inquiry and critical dialogue. According to Lew, effective science literacy instruction requires providing authentic reading practices and equipping students with strategies tailored to the structure and language of scientific texts, rather than relying solely on general reading approaches (Lew, 2024). Scientific literacy also depends on students' understanding and use of both general academic vocabulary, such as “analyze” and “correlation”, and discipline-specific terminology critical for engaging in scientific reasoning and argumentation. Collaborative learning plays a vital role in fostering science literacy.

Through peer discussions, group investigations, and shared meaning-making, students learn to articulate ideas, question assumptions, and construct scientific understanding together. Engaging with multimodal resources, such as digital simulations, data visualizations, and hands-on laboratory experiments, further enhances science literacy by allowing students to interact with content in meaningful, applied ways that strengthen both conceptual understanding and scientific communication.

Science literacy is a multifaceted construct that encompasses reading, writing, speaking, and listening within scientific contexts. It empowers students to think critically, communicate effectively, and participate authentically in scientific practices. By integrating literacy and science instruction, educators can support deeper learning and ensure that all students, regardless of language background and reading ability, have access to and success in science education.

Literacy as a Foundation for Scientific Understanding

Literacy serves as a foundation for scientific understanding because it enables students to access, interpret, and communicate scientific information effectively. Literacy, encompassing reading comprehension, writing, vocabulary knowledge, and oral discourse, is foundational to understanding complex scientific ideas. This encompasses not only the comprehension of scientific texts and the articulation of scientific concepts but also the use of language as a tool for inquiry and dialogue within the discipline. In modern educational practice, these skills are critical in helping students access and engage with scientific content. Wright underscores the emphasis placed on language and literacy within national and state science standards, noting that they serve as essential tools for students to articulate scientific reasoning and participate in classroom discourse (2019).

Scientific texts often contain complex structures, discipline specific vocabulary, and multimodal representations, such as diagrams, equations, and models, all which require strong literacy skills to analyze and effectively communicate the concepts. Students must be able to decode technical language, analyze evidence-based claims, synthesize qualitative and quantitative results across multiple sources in order to form cohesive evidence based responses. Without the meaningful incorporation of literacy in instruction approaches, students may struggle to grasp the meaning of scientific phenomena, apply concepts to new situations, or engage in authentic scientific practices because reading, writing, and speaking is consistently seamlessly integrated into scientific practices. Literacy fosters critical thinking by encouraging students to ask questions, evaluate the credibility of sources, and construct logical arguments based on evidence (Kowalski et al, 2025). These are core components of scientific reasoning and the scientific process. Through reading and writing in science, students learn how knowledge is developed, challenged, and revised over time, mirroring the real work of scientists. In essence, literacy is not just a support for learning science, but an integral process of doing science. By developing student's literacy skills in tandem with science, educators are laying the groundwork for deeper conceptual understanding and are creating a more equitable access to science education for all learners.

Challenges in Classrooms

In 2024, 39 states experienced a decline in fourth-grade reading proficiency, both nationally and in large urban school districts between the score reports of 2024 to 2019. Similarly, 38 states reported decreased reading proficiency among eighth-grade students in public schools and urban settings. Although the overall drop in scores between the 2022 and 2024 reports was less pronounced, both grade levels still showed a downward trend in reading performance (NAEP, 2025). Despite the recognized benefits of literacy integration, science instruction is frequently marginalized in elementary classrooms. The prioritization of reading and math due to standardized testing pressures often results in reduced instructional time for science. In elementary education, subjects are often taught in isolation, resulting in a greater emphasis on reading and writing while science instruction is frequently overlooked or minimized.

In 2022, only 32% of fourth graders read at or above proficiency, a decline from 38% in 2015, prompting schools to intensify literacy instruction while science is deprioritized (NAEP, 2025). As a result, only 36% of fourth graders demonstrated proficiency in scientific inquiry, highlighting a critical gap in early science education. Wright explains that this imbalance in instruction leads to missed opportunities for meaningful integration, as teachers focus on language arts to the detriment of science (Wright & Domke, 2019). Furthermore, limited access to quality science curricula and inadequate professional development restrict teachers' ability to integrate science and literacy effectively is a common theme among literature. These structural barriers hinder the development of foundational scientific literacy in early learners.

The Urgency of Integration

The call to integrate literacy into science education is not simply about improving test scores, it is about cultivating the next generation of scientifically literate citizens who can synthesize and critique information. Combining these domains enhances comprehension of scientific texts, supports the development of academic language, and empowers diverse learners, particularly emergent bilingual students (Lew, 2022). This integration also promotes inquiry-based learning and real-world problem-solving, critical for STEM readiness. When students see how literacy enhances their ability to question, analyze, and communicate scientific ideas, they engage more deeply and perform more confidently (Kowalski et al, 2025). Research shows that schools that adopt integrated curricula see improvements in both literacy and science outcomes (Kowalski et al, 2025; Shelton et al, 2023).

The Role of Literacy in Science Instruction

Teachers play a pivotal role in shaping students' science identities by creating classroom environments where learners internalize experiences and navigate the socially constructed and evolving roles involved in "doing science". Students develop a science identity when they see themselves as knowledgeable and motivated in science, actively participate in scientific practices, and are recognized by themselves and others as capable and valuable members of the science community (O'Brien et al. 2023). Through their instructional choices, teachers position students within the scientific community. By designing equitable, sense-making opportunities that support diverse ways of thinking, speaking, acting, reading, and writing like scientists, teachers foster the development of students' science identities and stimulate sustained interest in the discipline (O'Brien et al., 2023).

In secondary education, where content becomes more abstract and discipline-specific, literacy plays a pivotal role in navigating complex scientific texts, such as in chemistry, biology, and physics. Instruction must focus on strategic reading practices, including identifying main ideas, analyzing evidence, and synthesizing information across sources. This is particularly important for emergent bilingual students who must simultaneously decode language and scientific content. Lew emphasizes the need for scaffolding reading strategies and incorporating students' linguistic backgrounds to support equitable access to science learning (Lew, 2024).

Discipline-specific vocabulary instruction is another cornerstone of secondary science literacy. Students must acquire and apply technical language to read, write, and talk about science. Research advocates for teaching vocabulary through rich contexts, repeated exposure, and dialogue-based activities that deepen understanding (Anderson et al., 2023;

Lew, 2024). Anderson et al. (2023) asserts that explicit vocabulary instruction enhances students' ability to communicate scientific ideas effectively. Incorporating authentic texts, such as journals, informational articles, and multimedia resources, exposes students to real-world applications of science, reinforcing literacy skills while fostering content engagement.

Effective Strategies for Integrating Literacy into Science

Successful integration of literacy into science instruction involves a variety of strategies that promote engagement and deepen understanding. These include:

Explicit Reading Strategy Instruction

When incorporating reading into science classes, educators must provide an explicit and scaffolded approach with modeling of reading strategies of general and discipline specific strategies (Lew 2024). Students use general reading strategies across all disciplines " encompass predicting, bringing background knowledge, using context clues, recognizing genre features, concept mapping, questioning, visualizing, paraphrasing, note taking, and summarizing" (Lew, 2024, pg 1525). It is not simply enough to only use general-reading strategies in science class, because science requires students to be able to critically evaluate information. In order to have students be able to critically evaluate information and models, discipline - specific reading strategies must be explicitly incorporated and modeled.

Science specific reading strategies "include seeking evidence and identifying claims, evaluating scientific arguments, examining science words and language, connecting the discrete concepts in the reading to big ideas, and '[interpreting] the meaning of models presented in texts and diagrams" (Lew, 2024, p. 1525). Teaching students how to summarize, question, and organize information from science texts improves comprehension and retention by incorporating general and discipline-specific reading strategies (Lew, 2024).

An example of a discipline specific strategy is called "Promoting Adolescents' Comprehension of Text (PACT)". Engaging in the use of strategies, such as PACT, to allow for students to engage in a text-and discussion-based approach with their engagement of literature in class. (Selton et al, 2020). Secondary science classes require students to understand expository texts in order to grasp scientific concepts. However, many middle school students, both with and without disabilities, struggle to access and engage with science content effectively due to barriers caused by weak literacy skills. To provide all students an opportunity to engage in literacy and the literature provided, educators can engage in PACT strategies in instruction. PACT incorporates a sequence of teacher led and student led parts to increase the points of entry for all students into the material. First educators will engage with their students a "comprehension canopy" and this allows for teachers to provide the essential background needed to make sense of abstract or unfamiliar content. Teachers will have an organizer of "essential words" that may be new to the student and allow for students to discuss with one another to draw a model or find related words to that word. One of the essential components of the incorporation of vocabulary is that it must not only be provided in a list, but also included in the literature, so that students will have the opportunity to engage with the vocabulary during the following step of PACT, where they are critically reading aloud the text with a partner. This provides students practice with both reading and speaking skills as they are taking turns both reading aloud and following along with their partner. By providing clear and explicit directions for reading practice, it allows students to understand their expectations on how they are to engage with the content, but it also creates a roadmap with scaffolded and manageable steps to engage with the content.

Using Phenomena in Enhancing Student Engagement

Phenomena-based instruction is a term used by state standards to promote authentic science instruction. Authentic science instruction promotes the real world-connection that can motivate students into learning discipline-specific vocabulary (Kowalski et al, 2025). Incorporating phenomena in science instruction has become increasingly recognized as an effective pedagogical strategy to boost student engagement and success in science. When educators use real-world phenomena as a starting point for inquiry-based learning, students are more likely to develop a deep understanding of science concepts by fostering both curiosity and enthusiasm for science. Teachers should choose phenomena that are relevant to students' interests and community contexts. This may include local environmental issues, everyday occurrences, or global challenges that resonate with students' lives (Bailey, 2023). Incorporating local or widely known phenomena, such as weather patterns, plant growth, or ecological interactions, can make learning relevant and relatable (Sisgaard & Preston, 2025). Teachers can leverage current events or seasonal changes to connect lessons to phenomena that students observe in their daily lives (Anderson et al, 2023).

To effectively incorporate authentic, phenomenon-based science instruction, educators need intentional support and resources from school and district leaders. School leaders and administrators should build dedicated time into master schedules that allows for the integration of literacy and science instruction. Collaboration among literacy teachers, science teachers, and school librarians is essential. By working together, they can ensure students have access to high-quality trade books and science journals that connect to classroom learning and deepen students' understanding of scientific concepts. Teachers should be provided with professional learning (PL) opportunities that are intensive, sustained, and directly aligned with classroom instructional plans. This scheduling support enables teachers to create more cohesive and meaningful learning experiences across disciplines. Schools should acquire and promote the use of science-related written materials that support authentic engagement in reading, writing, and inquiry-based science activities. These materials should emphasize real-world phenomena and be relevant, grade-appropriate, and aligned with the science content being taught. These opportunities should offer concrete instructional models so teachers can envision and implement what integrated science and literacy instruction looks and feels like in practice.

Contextual Vocabulary Development

Using word walls, semantic maps, and dialogic activities helps students internalize and apply scientific terms (Anderson et al. 2023). Sigsgaard and Preston emphasized the importance of addressing the language of science to enhance students' understanding of scientific concepts. Integrating language instruction seamlessly into science lessons, rather than treating it as a separate component, enables students to more effectively access and engage with scientific content (2024). Effective literacy integration supports students' ability to comprehend scientific texts, utilize discipline-specific vocabulary, and engage in critical thinking. Anderson et al.'s research highlights how vocabulary talk during early science instruction helps students build meaningful connections between terms and scientific concepts, promoting deeper understanding (2023). In order for students to be successful in science, they must learn general - academic vocabulary and discipline - specific vocabulary and understanding general - academic vocabulary leads to success understanding discipline - specific texts and influences success across academic disciplines (Lew, 2024). Moreover, incorporating explicit strategies like breaking vocabulary words down into their separate meaningful parts and contextual clues fosters metacognitive awareness and strengthens students' ability to decipher complex terminology.

Teaching vocabulary in isolated words lacks deep and rich understanding and promotes rote memorization. Through active exploration and discussion, students are able to develop a rich and complete understanding of new vocabulary words and will reinforce discipline - specific vocabulary. Kowalski, Hashim, and Peters explain how “literacy-rich experiences strengthen both content knowledge and language skills, making science an ideal context for vocabulary development that benefits all areas of learning” (Kowalski et al, 2025, pg. 4). The focus on meaningful integration vocabulary can be done through collaborative planning for teaching across disciplines, and shared planning time for literacy and science teachers to design supports to integrate vocabulary into science instructional materials for students (Kowalsk et al, 2025).

Use of High-Quality Texts

High-quality texts in science are those that engage students in authentic scientific practices while promoting critical reading, vocabulary development, and conceptual understanding. These texts include informational books, scientific articles, biographies, and digital media that reflect the structure and language of scientific discourse. High-quality texts are not limited to factual accuracy; they also represent diverse perspectives, genres, and backgrounds to support students’ science identities and deepen their connection to the subject (Love et al, 2924; Lew, 2024). When carefully selected, these texts serve as tools for disciplinary literacy, helping students build connections between prior knowledge and new scientific concepts while navigating the unique linguistic features of science. They play a key role in fostering equitable sensemaking. For instance, using topical science texts and texts by or about individuals from underrepresented backgrounds can develop students' literacy skills and help them co-construct inclusive understandings of science and scientists (O’Brien et al., 2023).

Teachers can leverage high-quality texts in science instruction to enhance literacy and deepen student engagement with content. By integrating diverse and content-rich texts into lessons, educators expose students to scientific vocabulary, complex sentence structures, and discipline-specific ways of thinking (Wright & Domke, 2010). To make this integration effective, teachers can employ instructional strategies such as guided reading, vocabulary talks, and collaborative discussions that emphasize meaning-making. For example, Anderson et al. (2023) highlight the importance of vocabulary talk in science instruction, where student discourse around word meanings promotes understanding and retention. High-quality texts also serve as platforms for inquiry-based learning activities such as group projects, presentations, and experiments that are grounded in the content of the readings. Additionally, using multimodal materials—including digital texts, simulations, and interactive visuals—supports diverse learning styles and strengthens students' ability to interpret scientific information across formats. Together, these practices create a robust framework that links literacy to science learning through dialogue, analysis, and authentic application.

To successfully incorporate high-quality texts into science instruction, educators need a strong foundation in both disciplinary content and literacy pedagogy. First, teachers must understand what constitutes a high-quality science text and how to evaluate materials for content accuracy, relevance, and inclusivity. This includes curating text sets that align with curricular goals while also reflecting the voices and experiences of diverse communities to engage all learners (Lew, 2024). In addition to content knowledge, educators require access to professional development that models effective strategies for integrating texts into instruction—such as scaffolding techniques, discourse facilitation, and questioning frameworks that support critical thinking and comprehension. Differentiation is also essential. Teachers should tailor instruction to accommodate varied reading levels and language proficiencies, using tools like graphic organizers, visual aids, and multilingual supports to enhance accessibility (Lew, 2024). Finally, educators must cultivate a classroom environment where curiosity, inquiry, and collaborative discussion are encouraged. A positive reading culture in science not only supports academic growth but also helps students build confidence as readers, thinkers, and future scientists (Bailey, 2023).

Collaborative Learning and Discourse

Student discourse is essential for meaningful learning in science. When students talk, argue, and explain their thinking, they actively engage in scientific reasoning and strengthen their language and literacy skills. Integrated literacy and science instruction that emphasizes conversation helps students develop inferential thinking, a key predictor of reading comprehension. (Kowalski et al, 2025). Rather than passively completing routine experiments, students should be encouraged to discuss their observations and use evidence from data and texts to support their ideas. A classroom rich in discourse fosters deeper learning and accelerates growth in both science and literacy.

Collaborative learning environments promote the use of questioning techniques and reasoning skills, which are fundamental for scientific inquiry. Students are encouraged to ask questions and seek evidence collaboratively, facilitating deeper engagement with the material and improving their comprehension of complex texts. The Next Generation Science Standards highlight the importance of integrating language and literacy development within scientific practices, suggesting that through structured discussions and collaborative experiments, students can be apprenticed into the discourse of science.

Collaborative learning in science education serves as a powerful tool for enhancing literacy skills among students by fostering communication, critical thinking, and collective problem-solving. Through collaborative science activities, students engage in discussions, share diverse perspectives, and collectively construct knowledge, all of which are essential elements of developing disciplinary literacy. For instance, group projects where students investigate scientific phenomena encourage them to articulate their findings, justify their reasoning, and negotiate meaning with peers. This process not only supports their understanding of scientific concepts but also enhances their ability to use scientific language effectively in context (Wright & Domke, 2019). Collaborative learning and discourse fosters an interactive environment where all students are able to engage and construct knowledge together and practice communicating effectively. This collaborative approach encourages students to articulate their understanding and others, enhancing both scientific and language literacy (Love et al., 2024). This collaborative approach can look like structured peer discussions, partnered readings with guided questions throughout, and think-pair-share activities. Collaborative approaches in multilingual classrooms can significantly support language development and enhance the overall learning experience for students from diverse linguistic backgrounds. By engaging in collaborative learning structures, students have the opportunity to communicate, negotiate meaning, and support one another in the learning process, which is essential for language acquisition (Lew, 2024).

Talk moves are strategies used by teachers and students to foster meaningful and productive classroom discussions, particularly in science and other inquiry-based subjects. These moves help students articulate their thinking, actively listen to others, and build on ideas using evidence and reasoning (Soysal, 2022). Common talk moves include revoicing, where a teacher or student paraphrases another's idea to clarify or emphasize it, and asking for clarification to encourage deeper explanation. Prompting for evidence or reasoning helps students support their claims with data, while asking others to respond promotes peer-to-peer engagement. Teachers may also ask students to repeat what a peer said in their own words to reinforce listening and understanding, or invite others to "add on" to ideas to encourage collaborative thinking. Incorporating wait time after posing questions is another important talk move, giving students space to process and respond thoughtfully. Together, these strategies shift the classroom dynamic from teacher-centered instruction to student-centered discourse, supporting critical thinking, scientific reasoning, and inclusive participation.

To design lessons where scientific discourse is the central instructional practice teachers need a range of support. Educators require professional learning focused on strategies for facilitating productive discussions, including the use of talk moves, sentence stems, and evidence-based argumentation (Soysal, 2022). Teachers also need adequate instructional time and flexibility in their pacing to allow for extended student conversations rather than simply covering content. Access to high-quality phenomena and instructional materials that include built-in prompts for discussion is essential. Collaborative planning time with colleagues, especially across science and literacy disciplines, supports the development of integrated, discourse-rich lessons. In the classroom, teachers benefit from established norms and visual supports that create a safe and structured environment for student talk, particularly for English learners and students with disabilities (Lew, 2024). Finally, strong administrative support and a school culture that values inquiry and student voice help sustain and prioritize discourse-centered instruction.

Conclusion

To prepare students for success in science and beyond, literacy must be viewed as a foundational element of science education. This literature review demonstrates that integrating reading, writing, vocabulary development, and discourse into science instruction supports students' ability to think critically, engage in inquiry, and communicate scientific understanding, skills essential for becoming scientifically literate individuals at all ages. Whether in elementary classrooms building early scientific curiosity or in secondary settings tackling discipline-specific texts and concepts, literacy enables students to access content, make sense of complex ideas, and participate meaningfully in scientific practices.

Each section of this review highlights a key component of effective integration. The introduction establishes the need for a cohesive approach that supports literacy development across K–12 classrooms, especially for students with disabilities and multilingual learners. The section on literacy as a foundation for scientific understanding emphasizes that reading, writing, and discourse are not add-ons but central to engaging with scientific knowledge. The challenges in the classroom section identifies the structural barriers, such as limited instructional time and inadequate materials, that hinder integration, particularly in early grades. The section on the urgency of integration calls for schools to adopt instructional models that promote inquiry, real-world application, and equity.

The role of literacy in instruction focuses on the importance of identity development, vocabulary acquisition, and reading strategies for deeper understanding in secondary science. Effective strategies such as PACT, vocabulary instruction, and use of phenomena show how teachers can actively support student learning through intentional literacy practices. The section on high-quality texts explains how access to diverse, engaging, and content-rich materials is essential for literacy and identity development. Finally, collaborative learning and discourse reinforces that productive student talk is vital for both science understanding and language development.

For educators to be successful in this work, they need access to high-quality instructional materials, structured opportunities for professional development, and dedicated time for interdisciplinary planning. They must be equipped to model disciplinary reading strategies, scaffold vocabulary instruction, and facilitate rich student discourse. Administrative support is critical to foster a school culture that values inquiry, collaboration, and student voice. Educators also need tools and training that help them differentiate instruction for diverse learners and use phenomena and texts that are relevant and responsive to students' lived experiences.

To be a successful scientist, whether as a curious child or a professional researcher requires more than knowledge of facts. It requires the ability to read scientific texts, ask meaningful questions, communicate ideas with evidence, and collaborate with others. Literacy is not separate from science, it is how science is done. Equipping teachers with the tools and support to integrate literacy meaningfully into science instruction is essential for ensuring that all students can access, engage with, and contribute to the scientific world.

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SECTION I

Chapter 3 - Jack, a Beanstalk, and the Science of Reading

Kristen A. Poindexter

Chapter Highlights

- Using children's literature that is included in most Science of Reading curricular materials can help classroom teachers also teach science concepts.
- Shifting thinking to include Science of Reading elements in science lessons enables teachers to cover both areas of the curriculum.
- Teachers can use the existing framework in their Science of Reading curricula and use that to plan science content-based lessons.

Introduction

With the recent emphasis on shifting the teaching of reading to strategies aligned to the Science of Reading principles, many classroom teachers are not only shifting their thinking about teaching reading and phonics to their students but also left with little time to teach other content areas, specifically science and social studies. The introduction to the science of reading was quick for so many teachers and left them with more questions than answers. Schwartz (2022) examined several of the difficulties in implementing science of reading in elementary classrooms, including lack of teacher training and the access to materials that align with the science of reading. As a classroom teacher struggling with these ideas myself, I attended workshops and trainings and searched online for materials that would help me teach my students in ways that are aligned to the science of reading.

My school district adopted a science of reading based curricular series, CKLA (Amplify, 2025), which is based on the Core Knowledge sequence of topics (Core Knowledge Foundation). CKLA is constantly updating its curricular materials and the last several updates have aligned with the science of reading principles, including phonemic awareness, phonics, fluency, comprehension, and vocabulary. CKLA (Amplify, 2025) is divided into two separate areas of study, Skills and Knowledge. CKLA (Amplify, 2025) provided my first, hands-on introduction to the science of reading in action and gave me a general framework with which to follow in each lesson. As Schwartz (2022) noted teaching in the framework of the science of reading would be a big change from the methods I was taught and have learned over the last 20+ years in the classroom. As I taught the first few lessons, which were 1 hour in length each for both the Skills and Knowledge portions, I wondered how I would be able to include more science instruction in my schedule, given that I was left with very little time in my day to do so. Many of the Knowledge topics were science and social studies themed, however, they did not dig deeply into the science content or focus on our specific science standards.

To ensure that my students would be able to have access to the science content, I began to investigate ways in which I could include both science and the science of reading content in one lesson. Bailey (2024) recommends, “integrating the teaching of reading and academic content”. This is especially necessary for science, where only 17 percent of K-3 students and 35 percent of 4th-6th grade students are receiving science instruction all or most days of the school year (Smith, 2020). Bailey (2024) also offers these instructional practices for teachers who would like to elevate [science] content knowledge to a more primary role. First, teachers can diversify their read-aloud content, Next, teachers should develop high-quality comprehension questions along with dissecting academic and domain specific vocabulary. Finally, teachers can discuss word knowledge and desegregate language and literacy in science. These suggestions along with my own work studying literacy and science (Poindexter, 2024), helped me to develop a lesson to elevate science in the science of reading. As we had studied fairy tales previously in one of our knowledge units, and I have determined their use to be effective in teaching nature of science aspects (Poindexter, 2024), I decided to select a new fairy tale to use when developing this study. I chose fairy tales as they are highly engaging, and many students have listened to them previously. I also chose to work in fairy tales as many of them have a related science concept that we can link with, for example plant life, weather, and engineering.

Fairy tales also tend to provide rich vocabulary and many ways for students to share their comprehension of each story. For this lesson, I will be using the fairy tale, Jack and the Beanstalk (Nelson, 2021). I selected this fairy tale because it contains several vocabulary words my students may not know, it will allow me to determine their level of comprehension, and I can pair it with an immersive experience (Poindexter, 2024) to help my students learn about nature of science aspects along with our science standards about plant growth and plant parts. In completing this study, I will be working to determine if using two science of reading strategies, vocabulary and comprehension, along with our science standard about plant life will increase my students understanding of the vocabulary and comprehension of the fairy tale. Additionally, I will use classroom conversations to determine student growth of science concepts related to plant life and nature of science aspects. I will be determining if this method is effective using several methods of assessment including observation, conversation, and student response sheets. I will use the following research question to guide my study:

> Q: Were my students understanding of able to demonstrate an understanding of vocabulary terms introduced in this lesson and were they able to demonstrate comprehension of the fairy tale?

I also focused on the following Indiana Academic Standard to guide the science content in my lesson:

K-LS1-1 Use observations to describe patterns of what plants and animals (including humans) need to survive.

Literature

In recent years, the National Assessment of Educational Progress (NAEP) has shown a decline in student reading scores across the U.S. (U.S. Department of Education, 2002 & 2024). One of the recommendations that has come from this report is the need to include components in literacy instruction that will help students become better readers. The National Reading Panel Report in 2000, complied decades worth of research that showed that the five components should be: phonemic awareness, phonics, fluency, vocabulary, and comprehension. There are many curricular materials that support these five components, helping to ensure that teachers are including them in their daily instruction. For my lesson, I focused on the areas of vocabulary and comprehension as my students completed work in phonemic awareness, phonics, and fluency during other parts of the school day.

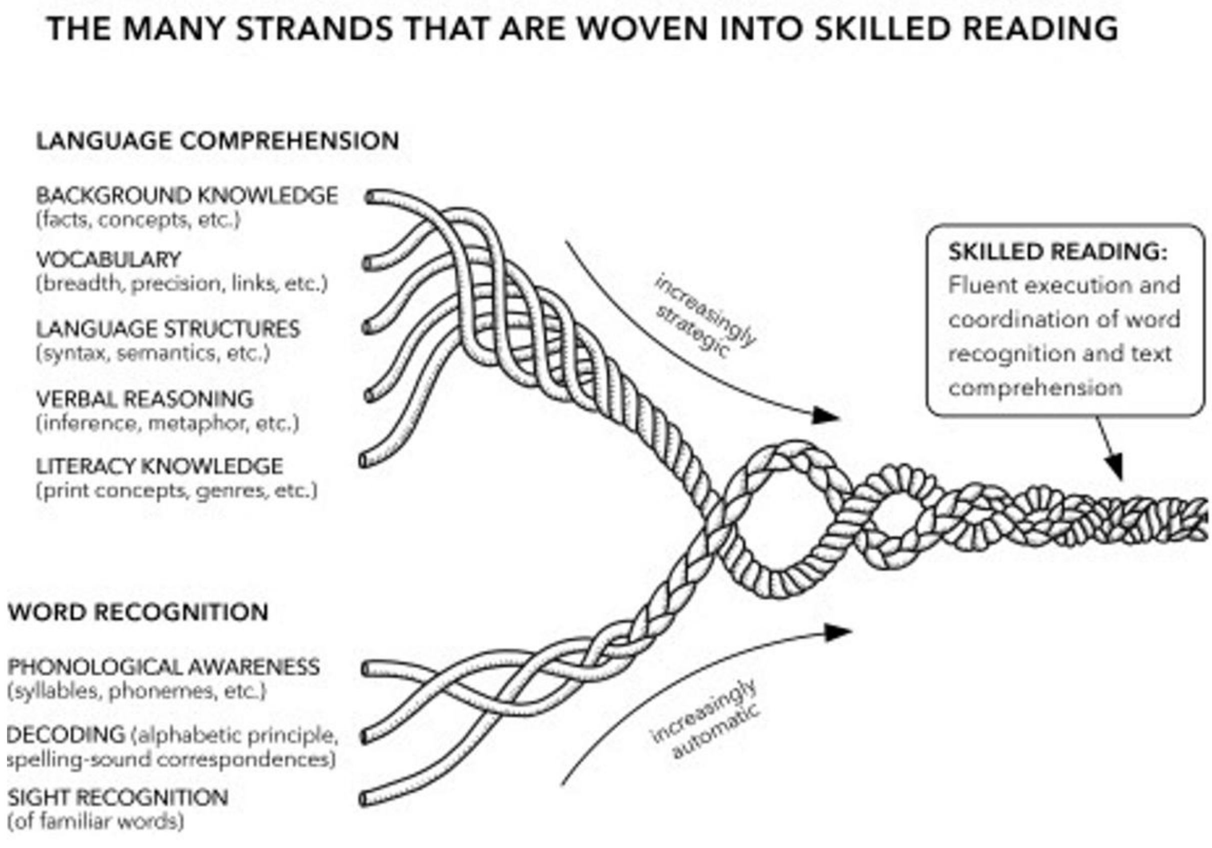

Figure 1. Scarborough's Reading Rope (2001)

Scarborough's Reading Rope (2001) (see Figure 1) shows how each of the suggested components intertwine with each other to help students become skilled readers. Kambach & Mesmer (2024) share that in many teacher professional development sessions the word recognition portions of the Reading Rope are those that receive more attention and training, whereas the language comprehension portions, specifically, comprehension and vocabulary are given less training time and attention, resulting in less use in classroom lessons. Scarborough (2001), also adds that even if a child knows all the letter sounds and can identify all the letters of the alphabet, and their oral language skills are behind, students will not be able to understand the vocabulary in text and will most certainly not be able to comprehend the text. Supporting students in the learning of phonemic awareness, phonics, and fluency is equally as important as giving students specific instruction in vocabulary and comprehension.

Vocabulary

Vocabulary development goes hand in hand with comprehension. If children do not understand individual words and phrases they are reading, they will be less likely to comprehend the text overall. Rawlins & Invernizzi (2019), shared that "The ultimate goal of reading hinges on the construction of meaning. Without understanding the printed words, readers cannot move through sentence- or discourse-level texts". Students need to have access to the vocabulary words before hearing the story so that they can construct meaning before even hearing the text or story. Many texts, especially nonfiction or informational texts, often have words that would be considered Tier 2 or 3 words for a student, meaning that they are not words used in their everyday conversations, and require more intentional instruction and emphasis for students to understand them. Guo et al., (2025) completed a study using informational texts with preschool students to help increase their understanding of science related vocabulary words. When the teachers in the study used targeted instruction of several specific vocabulary words, student understanding of those words increased and continued to increase over time, even when different science content related texts were used. Vocabulary development occurs when students learn the meaning of a new word or learn an additional meaning of a familiar word. (Anderson, 2024). In working with eight early elementary teachers, Anderson (2024), developed 10 "Talk Moves" that were used most often in helping students learn new vocabulary words. Those 10 strategies include: using and emphasizing target words, explaining and defining the target words, prompting target words and eliciting students' ideas regarding review words, and using target words with a hint, visually displaying target words, and acting out/demonstrating target words. Most of these strategies were used in developing this lesson and are the strategies that are also used in my curricular materials.

Comprehension

Kambach and Mesmer (2024) define comprehension in several parts. First students need to be able to understand sentences at the sentence level and find the main idea to make meaning of the text. Second, a reader needs to take multiple sentences and connect the main ideas across several sentences, such as those in a paragraph or page, to gather a larger chunk of meaning. Finally, students need to piece together each of the main ideas to make sense of the text and comprehend what they are reading. Ideally, most text for students would be on their grade level to ensure that they are practicing phonemic awareness, phonics and fluency skills while reading, however, if students are not strong in these areas, they will have difficulty in comprehending the text (Scarborough, 2001). Daniel et al., (2024) shares that when planning on sharing a text with students, with the purpose of increasing student comprehension, the teacher should begin by setting the pupose for reading along with giving a very brief introduction of the text so that studetns have some frame of reference for their reading. Additionally, they suggest that longer, more complex texts should be broken down into smaller sections for students to reflect on before moving on to the next section. In a whole group read aloud, the teacher would pause every few pages and ask several comprehension questions or allow students to turn and talk with peers to share their understanding. Finally, Daniel et al., (2024) suggests that after reading the text, the teacher asks more comprehension questions along with several related to the introduced vocabulary words. In this lesson, I used questioning before, during, and after reading Jack and the Beanstalk to students to build in many comprehension questions to ensure student understanding of the text.

Method

As I am a practicing classroom educator, I chose to use an action research study methods to determine my actions as a teacher on my students' growth in their use of vocabulary, comprehension skills, and understanding of nature of science aspects. In addition to the intervention I created and taught, this study was conducted using action research methods as defined by Yin (2016), using five features of action research:

1. “Studying the meaning of people’s lives, in their real-world roles.
2. Representing the views and perspectives of the people (participants) in a study.
3. Explicitly attending to and accounting for real-world contextual conditions.
4. Contributing insights from existing or new concepts that may help to explain social behavior and thinking.
5. Acknowledging the potential relevance of multiple sources of evidence rather than relying on a single source alone.”

During this study, I researched the effects of the intervention on increasing young children’s understanding of specific vocabulary from the fairy tale, increasing their comprehension of the fairy tale and increasing their understanding of NOS aspects. I studied Kindergarten students (participants) in their regular classroom environment, as they interacted and made new meanings with peers to solve each case. The study took place for one week. 11 out of 24 students in the classroom were given consent to participate in this study by their guardians. I set up a microphone up in the middle of the classroom and was able to capture whole class conversations, students agreeing or disagreeing with peers, and conversations between peers. Audio recordings helped me to listen more closely to student understanding of Jack and the Beanstalk, introduced vocabulary, and use of NOS aspects.

Action Plan

Below is a detailed plan of the lesson that I taught to my students. It is written so that it can be easily replicated in other classrooms and the parts related to the science of reading are based on the framework from the CKLA Knowledge curriculum.

Title: *Jack and the Beanstalk* by Thomas Nelson
Overview: Using the children’s book *Jack and the Beanstalk* as an introduction, students will examine an age appropriate “crime scene” staged to look as though as if a giant might have fallen from the sky. Students will learn to use observation and inference to find clues to determine if the giant is still alive. Students will be introduced to vocabulary from the story before it is read aloud to them. Comprehension questions will be asked throughout the

reading of the text.
Investigation Question: What happened to the giant after the beanstalk fell?
Materials: -giant cut out (trace around a tall person on butcher paper and cut out) -hen -plastic egg painted gold -gold harp -Jack's footprints 4-5 -plastic ax -small parachute -3 manilla file folders -3 small envelopes (to place clues into), label with Clue 1, Clue 2, Clue 3
Prep: Before students enter the classroom, set up the crime scene. Begin by wrapping crime scene tape or rope/yarn around the legs/holes in the back of chairs (one can be knocked over) to cordon off an area where all of the artifacts will be placed. Place the giant cutout in the crime scene area. Place these artifacts in the crime scene as well: hen, plastic egg, gold harp, Jack's footprints, plastic ax, and the small parachute. Place Jack's footprints going in the same direction, as if they might be walking away. Place each character's Case File page into a manilla folder and paper clip it to the right-hand side of the file folder. Place each clue into the correctly labeled envelope.
Day 1: The instructor will ask or review with students what they know about the word observation and create a t-chart with the student responses on one side. The instructor will repeat the same activity using the words inference, subjectivity, the tentativeness of science, creativity and empirical evidence. If students have difficulty responding, the instructor will provide some examples of observation, inference, subjectivity, the tentativeness of science, creativity and empirical evidence at an age-appropriate level. This chart will be used throughout all the lessons so that the children are able to refer back to it as needed to clarify their understanding about these aspects of NOS.
Day 2: Students will gather on the floor together. Before reading the story to students, the teacher will introduce three important vocabulary words from this version of the story, Jack

and the Beanstalk (Nelson, 2021). Using the strategies developed by Anderson (2024), vocabulary was introduced using these steps:

1. Say the word aloud and ask if any students know what the word means or if students have heard the word before.
2. Define each word for students in kindergarten friendly language and then ask students if they could use the word in a sentence.
3. Say the word together several times and then ask students to tell a friend near them what the word means.
4. Show students each vocabulary word written on an index card and practice saying the words again when we saw each one.
5. Create a movement (listed next to each definition below) so that when students hear the word, they could show the movement to indicate they heard one of the vocabulary words.

Vocabulary introduced in this lesson:

Possession- things that you own or things that belong to you (movement: put both arms out front and then draw them in towards yourself, as if you are collecting everything)

Tremendous- something that is very big or large (movement: open arms out to the side to show something tremendous

Thundered- yelled or stomped very loudly (movement: stomping feet loudly, in an angry way)

Students will gather on the floor and the teacher will read to them the chosen version of Jack and the Beanstalk (Nelson, 2021). When students hear the specific vocabulary words as the story is read, they can use the movements to show they heard the word and can connect the correct movement to it.

After reading the story, ask the following questions to develop their comprehension of the story. When answering questions in my classroom, students have a partner, and they will always discuss their answer with their partner first before raising their hands to indicate they have a response for me. Students also talked with their partner during this lesson and before they answered any of the comprehension questions.

Comprehension questions: 1. Why did Jack have to sell their family cow? 2. How did Jack feel after trading their cow for magic beans? How did Jack's mother feel? What evidence do you have? 3. How do you think Jack felt when he saw the beanstalk? 4. How did the giant make Jack feel? 5. Why did Jack take the hen and harp with him? 6. How do Jack and his mother feel at the end of the story versus how they felt at the beginning of the story?
Day 3: Invite students to gather around the crime scene. Ask them to observe what they can see and write down their observations on a large chart paper. Once all observations have been collected, ask students to make inferences about what happened in the crime scene. Record inferences on another large chart paper. Follow up asking students to tell you what evidence they have from their observations that help to make their inferences true. Have students discuss their ideas with partners before inviting students back to the larger group to share their thinking. As students share their ideas, remind students that science is subjective, tentative and helps us collect empirical evidence. Ask students if there were any ideas from peers that changed their thinking or affirmed it, and how their thinking was changed. The teacher can use the following questions to prompt students if needed: "What did you observe?" "What did you infer from that data?" "What information changed your thinking?" "How were you creative in solving this case?" Additionally, the teacher will ask students to talk about how they were creative in using science during the crime scene activity. Students are able to take video and still photographs of the crime scene and add annotations or voice-recordings to share their thinking thus far in solving each case. Finally, students will complete the recording sheet where they can draw items from the mock crime scene that they are observing that are leading them to make inferences about the crime that occurred.

Day 4: The teacher will begin this part of the lesson by introducing three new clues or alibis that were developed to remind students that science is tentative and subjective. Each clue or alibi is written in a way that creates new thinking about previously known observations and inferences. Additionally, students will be introduced to a case file about each of the main characters from each fairy tale to give some evidence to students about each character's past. The teacher will gather students back as a large group to review and debrief the case files on each character and after giving students time to share with a partner, will lead a discussion with the whole group about making sense of the new information. The teacher will ask students if their thinking has changed based on the new information and remind students that science is subjective and tentative and that scientists are creative. The children can use the case files along with their observations and inferences to determine the solution to each case. Ask students to support their claims with evidence from their observations and inferences. The teacher will ask questions such as, "What did you observe?", or "What did you infer from that data?", "What information changed your thinking?", "How were you creative in solving this case?"
Day 5: The teacher will begin this lesson by asking if there are any students who would like to share their final thoughts with the whole class. Students will then complete a digital inference sheet designed by their instructor where the students have the opportunity to draw, record, or voice over a photograph indicating how they solved the case. When students have completed their reflection, the teacher asks students if they would like to plant some "magic beans" (lima beans that were spray painted gold). The teacher leads the students in a discussion of what the needs of the plants are so that they can grow, based on the Indiana Academic Standard for science; K-LS1-1 Use observations to describe patterns of what plants and animals (including humans) need to survive. The teacher ensures that the students have the materials needed to plant seeds in the soil, water them, and place them in a window or space with a light source. The growth of the plants was tracked over time until the plants were big enough for students to take home or transplant outside.

Data Collection and Analysis

During this study, I worked on answering this question:

> Q: Were my students understanding of able to demonstrate an understanding of vocabulary terms introduced in this lesson and were they able to demonstrate comprehension of the fairy tale?

I collected data from my students through whole group conversations that were audio recorded and from one recording sheet. Each conversation we had as a whole group helped me to listen to student thinking and to listen for the vocabulary words that were explicitly taught along with comprehension responses. Additionally, as I was listening to student discussions, I worked the vocabulary words into conversations or phrased my questions so that students could work them into the conversation and have practice using them in context.

To help me analyze my data, I tallied how many times students used the vocabulary words that I introduced anytime we were discussing Jack and Beanstalk. As students were sharing with their partners their interpretations of the vocabulary words, I moved around the room and listened to their conversations and made corrections or suggestions to students as necessary. I also asked students to complete a sheet that asked them to make a drawing of the mock crime scene to help determine what evidence they were using to find out what happened to the giant. Asking students to draw the crime scene allows students to comprehend what they are observing and make sense of what the important aspects of the scene are.

Results

In this study, I was researching methods to help my students increase their use of introduced vocabulary words and increase their comprehension of the fairy tale, "Jack and the Beanstalk". I used the following research question to guide my work.

> Q: Were my students understanding of able to demonstrate an understanding of vocabulary terms introduced in this lesson and were they able to demonstrate comprehension of the fairy tale?

Overall, students were able to increase their understanding of both vocabulary words and comprehension of the story. The whole group discussions helped students to bounce their ideas off of each other and listen to the thinking of their peers. Several students changed or added to their thinking or ideas after hearing the ideas of another peer, which added to their comprehension of the story in a different way. Students identified the vocabulary words in the story as they hear them and most remembered to act out the words using the movements we created together. Several students were caught up in listening to the story that they did not remember to act out the words until peers around them did so. When examining the mock crime scene, many students used the vocabulary words from the fairy tale to help explain their inferences.

Vocabulary

This conversation happened the day after reading Jack and the Beanstalk and was a review of the vocabulary words. I was checking to find out how long students were holding on to the vocabulary words and their definitions.

> **Teacher:** Remember back to before we read this story, we talked about the big words at the beginning, one of the big words was the word possession. What does it mean if you have a possession? Possession. So, if I say that the hen and the harp were the possessions of Jack and his mom, what does that mean?
>
> **Student 1**: It means it was theirs.
>
> **Teacher:** What does thundered mean? Remember, in the story it said, the giant thundered.
>
> **Student 2:** It was loud, right? The giant made loud noises like thunder is loud.
>
> **Teacher:** The other big word we learned was tremendous. That one means…?
>
> **Students:** Big! Large!
>
> **Teacher:** Would you like to plant some tremendous bean stalks?
>
> **Students:** YES!
>
> **Teacher:** OK, we're going to plant them so we can hang them in the window.

When reviewing vocabulary words with the students after reading the fairy tale, I used context clues to help students accurately identify vocabulary words. I also asked students if they knew what the word "thundered" meant, knowing that would be a word more students would be able to identify with as we discussed thunder at length when talking about weather words. Finally, I prompted students with the word "tremendous" and gave silent wait time to find out if any students would jump in with the words "big" or "large".

Comprehension

Our comprehension discussion happened throughout the weeklong lesson. At the core of the lesson, we were trying to determine what happened to the giant when he fell from the beanstalk, so this was a question that kept coming up. After listening to the story and viewing the mock crime scene, along with hearing the extra clues and seeing each character's "rap sheets" students were changing their thinking almost daily.

> **Teacher:** What do you think happened to the giant? It's absolutely okay if you share your idea, and then someone else says something and it makes you change your thinking. If you want to put your hand back up, you can absolutely do that. Sometimes that's what happens when you hear the thinking of others.
>
> **Student 1:** I think they made friends because there's only two people.
>
> **Teacher:** So, you think the giant fell down the beanstalk, sorry, climbed down the beanstalk, and they became friends…
>
> **Teacher:** What happened to the giant?
>
> **Student 2:** I think he broke his leg and went to the hospital.
>
> **Student 3:** He fell down the beanstalk. The wall. Then he couldn't get out. But then. But then, Jack came and then tried to help the giant get out.
>
> **Teacher:** What happened to the giant?
>
> **Student 4:** I think he didn't have anywhere to go after his beanstalk got chopped down, so he lived with Jack and his mom.
>
> **Teacher:** So, you think he moved in with Jack and his mom?
>
> **Student 5:** He fell into the hole and Jack buried the giant. He buried him and got his families hen and harp.

The area of comprehension is where it is easier to see and hear students listening to one another and gaining new insights from peers. I do share with students that it is okay to change your mind even if you have already shared a response. I also try to let students keep the conversation moving without me stopping that flow. I will restate the question as needed or move the conversation along to the next question, but I believe that when I remove myself from the conversation, students will listen and learn from each other. Although this conversation was from a discussion after we viewed the mock crime scene, I do believe that it lent itself to increasing student comprehension of the fairy tale overall, so I let the conversation go on for about 5 minutes.

Discussion

I do believe that this lesson plan worked to increase my student's understanding of the vocabulary words and their comprehension of the fairy tale. I created this lesson after using the framework that is used in the CKLA (Amplify, 2025) as it is familiar to my students, and I wanted to determine how flexible it would be for me to use its sections to create my own lesson. As a passionate teacher of science content, I also wanted to ensure that I could include science content in this lesson and purposefully chose a fairy tale that incorporated plant growth in it. Additionally, I wanted to demonstrate for other teachers that including science content during literacy instructional times are a way to make sure students are receiving necessary science instruction.

This method was highly engaging for students and students were eager to share their thinking and build on their previous knowledge and ideas. When I introduced the vocabulary terms before we read the story, students were excited to learn some new words and their meanings. As I tallied up the use of vocabulary words over the course of the week, I noticed that the use increased over time. It was as if students needed time to become more familiar with the words before they were interested in trying them out in conversation. They very much enjoy it when we create an action to help them remember a word. Many times, students will be so involved in listening to the story, they will miss the vocabulary words, so I will either reread the sentence or emphasize the word when reading it, so that students become aware of it. Many students did use the words "thundered" and "possessions" when discussing the mock crime scene and were correct in their context of use. I did add in my own use of the vocabulary words at other time throughout the day so that students could hear them in use in different contexts. In using Anderson's (2024) vocabulary talk moves on a regular basis, I have noticed that students are more fluent at working through new vocabulary words with me, just as they were in this lesson. Students know the structure of how we will learn a new word together, how they will be able to turn and tell a partner what they think the word means, and then creating a movement to show the meaning of the word.

Inadvertently during this lesson, I was not able to ask students comprehension questions until the day after reading the story. We spent a good chunk of time reading the story and stopping to discuss different parts of the story and had to move on to preparing for lunch. When I asked students the following day each of the comprehension questions, I was very pleased with how well students were able to hold on to the details from the story and relay them back to me. I developed the comprehension questions so that they would meet students at different levels of understanding, and using Daniel et al (2024), guidance, I asked questions before, during, and eventually, after reading the story. I also developed questions that asked students to do some inferring work based on evidence from the text. I did add three additional questions that are numbers, 7, 8, and 9 below. I wanted to bridge the gap between vocabulary and comprehension by inserting these questions and guide students back to how they were used in the story.

1. Why did Jack have to sell their family cow?
2. How did Jack feel after trading their cow for magic beans? How did Jack's mother feel? What evidence do you have?
3. How do you think Jack felt when he saw the beanstalk?
4. How did the giant make Jack feel?
5. Why did Jack take the hen and harp with him?
6. How do Jack and his mother feel at the end of the story versus how they felt at the beginning of the story?
7. What were the possessions that giant had taken from Jack and his mother?
8. How did you feel when the giant "thundered"?
9. How was the word "tremendous" used in this story? What did it describe?

When I asked students to draw a picture of the mock crime scene, many students included detailed drawings, which showed me that they were comprehending important details in the crime scene. I gave these drawings back to students on the last day of our lesson and asked them to write or draw a final response to answer the question, "What happened to the giant after the beanstalk fell?". Many students used vocabulary words in their responses. One student wrote that "The giant thundered out of the hole and ran away". Another student shared that "Jack and his mom had their possessions back". This crossover between listening and writing emphasizes the importance of including all strands of the reading rope (Scarborough, 2001). Each of these areas of literacy work with the others to help students develop strong lanuage comprehension and word recognition strategies that lead to strong readers and writers.

Recommendations

After teaching this lesson, I would recommend that it be drawn out to two weeks in length to allow more time to incorporate the science content. This could be done by including more work with planting seeds or by including the reading of more non-fiction texts related to plant growth. I did this work later in our school year during a specific unit related to plant growth, however, teaching this lesson beforehand allowed my students to have some background knowledge about plant growth.

In the future, I plan to use more fairy tales that can be linked to science content or standards. This does seem to be an easier task to do in early elementary grades, but I am curious to know how upper elementary teachers could use this method to help include science instruction in their literacy time. Additionally, as a classroom teacher who tried this method, I would like to know of other teachers who implement it and what their outcomes are.

Finally, I would recommend that teachers personalize the comprehension and vocabulary words to best meet the needs of their students. Most of my students were familiar with vocabulary associated with plant growth, so I determined that my vocabulary words should relate more to the fairy tale rather than the science content. I would also add in 1-2 questions about the plant growth in relation to the beanstalk, such ask, "Did the beanstalk have all the things it needed to grow"? I would add in an additional question to help students separate the fictional growing of the beanstalk from the factual ways in which planted beans grow and how long the process takes. I did have several students who expected to find fully grown beanstalks the day after we planted our lima bean seeds, so we did have a quick discussion to clear up any misunderstandings.

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Chapter 4 - What is Read, Black and White? Strategies for Questions and Answers

Barbara King

Chapter Highlights

- Students and adult volunteers discover the importance of the relationship of water and animals.
- Through observations students share information with drawings and data about their experiments.
- Students and adult volunteers ask questions to learn more about their ideas about penguins and water resistance on their bodies.
- Students demonstrate asking different types of questions to comprehend findings through their drawings and writings.

Introduction

Young students are naturally curious learners and want to understand the world around them. They make connections to concepts that they have prior knowledge and then try to build relationships on new ideas. For example, children know that when it rains, they need to protect themselves from water, so they wear a raincoat and utilize an umbrella. But what about animals? Even kindergarteners know that animals don't wear clothing. However, they do ask how do penguins swim in the ocean and not get wet? Two of the Indiana Academic Standards for science, K-LS-1 & K-ESS3-1, address these queries concerning the relationships of water and animals. Furthermore, through observations and data collection children formulate their own new understandings. With the assistance of classroom volunteers each student can independently explore and experiment why the penguins' feathers stay dry as they swim and dive in the ocean.

We know that young children learn by posing questions about their world to help them make sense of their environments and the world around them hence asking the right questions is crucial for understanding new concepts. The science of reading focuses on new readers responding to all types of questions to enhance their comprehension skills (Deshmukh et al., 2022). One major problem in the classroom is the limited time a teacher has to answer and instruct students on asking all the questions that they need to formulate their own answers. When teachers have classroom volunteers who are trained in how to help students investigate and experiment through questioning and trial and error, the students can develop and construct their own meanings to text. Students can then draw and write explanations for their own observations and findings.

One key factor in our action plan is utilizing retired teachers or trained volunteers to facilitate the implementation of instructing, experimenting and recording the kindergarteners' responses to texts. The most important reason that retired teachers or volunteers are able to work one-on-one with students is that they are not restricted to time constraints unlike the classroom teacher. As a retired teacher with more than ten years of private individualized tutoring experience and a vast knowledge of literacy professional development, I am able to engage in direct instruction based on each student's responses. Utilizing nonfiction texts that combine a read aloud with a book that is structured such as the We Both Read (McKay, 2024) book series, where an adult reads a page followed by the child reading the companion page, I introduced scientific concepts in the lessons. During this time with each child, I asked prior knowledge questions, posed discussion queries about their interests and preferences and invited them to speculate on "I wonder" investigations about penguins. Instead of learning to read, volunteers can focus on reading to learn as they are modeling reading, vocabulary acquisition and thinking aloud strategies (Watanabe, et al., 2023). Furthermore, teachers are the most influential conversation partners for preschoolers and kindergarteners because they provide linguistically rich conversations (Buckley et al., 2023). Classroom volunteers continue the linguistically rich dialogue by facilitating individuals' own thought processes through their questioning techniques and listening to the child talk responses (Buckley et al., 2023). The major advantage in utilizing trained volunteers is the benefit of recording and documenting the discussion results of each session with every participant in order to analyze the results of the action plan.

By providing explicit instructions for students to improve their skills of comprehension, students need to be taught how to ask a variety of questioning techniques. In this chapter, the action plan will introduce the strategy of questioning to formulate new learning, retain information and to alter misconceptions as the students practice and engage in the activities. The science of reading and the basic foundation of science education are built on the ability of students to question the reasons why and how concepts are formed. The purpose of this action plan research is to foster the reader's comprehension by asking a variety of questions which include literal, inferential, evaluative and personal responsive type questions. As the kindergarten students experimented with why and how the feathers of penguins protect and helped them to stay dry when they spend a high percentage of their lives in water, they asked a variety of questions. Instead of asking closed-ending questions that only allowed yes/no responses or short mono syllable answers, students practiced asking literal questions, as well as higher level queries. For example, "What does waterproof mean"? or "What protects the penguins' feathers from being soaked"? The action plan taught students to ask inferential and evaluative style questions such as, "What did you observe as the water was dropped on the feathers?; Was it absorbed or repelled?; Why do you think this happened?; Why would the penguins be protected from the moisture of the water"? Then, the students were encouraged to share their personal responses to connect their own prior knowledge to the new learning. By explicitly teaching questioning techniques, the classroom volunteer will have a more comprehensive understanding of the new learning and understand a kindergarten students' ability to recall details and facts and to share their new ideas to others. Our results confirmed that by explicitly teaching questioning strategies to kindergarten students, the students developed deeper comprehension and vocabulary acquisition. The question this action plan seeks an answer for:

> *When teaching explicit questioning techniques to explore science, will students transfer that knowledge in their verbal exchanges as they ask their own questions and answer with improved accuracy and detail in discussions?*

Literature

Over the past four decades the research on teaching effective reading skills has included the framework of Scaffolding Reading Experience (SRE) which has two main principles. The need for interaction when reading to young children and the importance of student success (Graves & Graves, 1994). The framework consists of two major phases: the planning stage and the implementation phase. The planning phase involves the students' needs, the selection of text and the purpose of reading the selection. The implementation phase is the one I will focus on because of the three components of SRE. The pre-reading, during reading and post-reading activities all include a common denominator of questioning. During pre-reading, students are encouraged to do pre-questioning and prediction of the topic. During the shared reading the student and teacher search for answers to their questions and validate their predictions. Finally, the post reading component includes question and answer follow up with a discussion. The students were prompted to process the information they read with higher level thinking skills including, interpreting, analyzing and evaluating the new learning based on their prior knowledge or misconceptions.

Shared reading between the student and teacher promotes structured practice and fosters engagement through interactive questioning before, during and after reading the lesson (Browder et al., 2008; Hudson & Test, 2022; Lacin, 2023). In addition, shared reading of age-appropriate literature provides scaffolding for language and literacy skills through the interaction of the volunteer and student (Lacin, 2023).

This action plan utilizes the genre style of reading materials, We Both Read (McKay, 2024) in which a proficient adult reads alongside of the beginner reader. The books are designed so that the proficient reader introduces details and vocabulary and the beginning reader reads short and grade level appropriate texts. The classroom volunteer supports the reader by asking questions and pointing out text features to help the learner understand new concepts.

Oral Language

Enjoying a shared reading experience provides opportunities for the student and volunteer to build a relationship of trust in order to exchange verbal dialog for a meaningful conversation (NAEYC, 2009 as cited in Desmukh, 2022). We define conversation as a back and forth on a specific topic between the two participants in which there are at least two turns. This is critical in children's language development (Deshmukh et al. 2022). Children need the verbal support of adults in the classroom in order to develop critical language development (Zimmerman et al. 2009 as cited in Deshmukh, 2022). Coincidentally, an instructional strategy to build and improve a student's ability to discuss at a higher level of understanding is also called verbal scaffolding (Pentimonti & Justice, 2010 as cited in Deshmukh & Pentimonti, 2022). The difference between the framework of SRE and verbal scaffolding is that the first concentrates on reading skills during the three phases of reading and verbal scaffolds focuses on the verbal utterances to the questions asked by the adults. According to research there is a positive impact on students' language and vocabulary development in which they verbally discuss their learning (Deshmukh et al., 2022). This verbal exchange happens during extratextual conversations between young students and adults while the children are engaging in multiturn discussions (Cabell et al., 2015 as cited in Deshmukh, 2022). It was found that before professional development of teachers in which they were trained on improving higher level responses from students, the majority of teachers only had six or seven turns for conversation during shared book reading (Milburn et al., 2014 as cited in Deshmukh et al,. 2022). As researchers studied the extratextual conversation between teacher and child only 25% were questions. Most frequently the questions were yes/no style or single word answers, which did not allow for children to be challenged linguistically (Deshmukh et al., 2022). The advantage of utilizing an adult classroom volunteer working with one student at a time, is that the child may ask and talk as long as needed to understand the new concepts, and the volunteer can respond with language rich with vocabulary, deeper in inferential and evaluative exchanges in a time-relaxed environment.

Comprehension-Questioning

Listening comprehension is essential for a student to understand oral language at the discourse level (Hogan et al., 2014; Kim & Pilcher, 2016 as cited in Phalen & Chezan, 2022). Listening comprehension encompasses the skills of connecting prior background experiences and knowledge, extracting meaning from text read alouds, and communicative exchanges from a partner (Kendeou et al. 2020 as cited in Phalen & Chezan, 2022).

Research has found that listening comprehension develops in early childhood and is a positive predictor of reading comprehension (Cain & Barnes, 2017 as cited in Phalen & Chezan, 2022). One factor of reading comprehension is determined by the ability to ask questions, search for answers and evaluate the quality of the findings. Questions unlock the key to understanding and propels us forward into deeper comprehension thinking (Harvey & Goudvis, 2007). When a child practices these skills, we know that they are seeking to construct meaning through monitoring comprehension and interacting with text (Harvey & Goudvis, 2007). A young child's curiosity of wonder and why things are happening are the first authentic quest for answers.

The importance of instructing and modeling of meaningful questioning techniques is crucial to build a foundation of higher- level thinking and solving problems. In order to foster deeper understanding questions must range from simple recall to evaluative. These question types include literal, inferential, evaluative, personal response, predictive and reflective. The progression is as simple as who, what, when, or where to why and how.

Teaching Students to Ask Meaningful Questions

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To foster reader understanding, employ a variety of question types, including literal, inferential, evaluative, and person response questions, as well as questions that encourage prediction and reflection, moving beyond simple recall to deeper comprehension.

Here's a breakdown of different question types and how they can be used:

1. Literal Questions

   Purpose: Assess direct recall of information explicitly stated in the text.

   Examples: "What is the main character's name?", "Where does the story take place?", "What did the character do in the first paragraph?"

   Tips: Ensure answers are directly found in the text.

2. Inferential Questions:

   Purpose: Encourage readers to draw conclusions and make connections based on the text, going beyond what is explicitly stated.

   Examples: “What do you think the author means when they say…?”, “What can we infer about the character’s personality based on their actions?”, “What is the author’s purpose in writing this passage?”

   Tips: Encourage students to use evidence from the text to support their inferences.

3. Evaluative Questions:

   Purpose: Prompt readers to form opinions and judgements about the text, its content and the author’s choices

   Examples: If ______, then ______., “What questions do you have about ______?”

It was determined that students who were trained to ask and write higher quality questions scored higher on both literal and inference comprehension questions (Davey & McBride, 1986 as cited in Watanabe, Arner & McNamara, 2023). Furthermore, students’ responses to the questions demonstrate the skill of explaining, paraphrasing, bridging ideas, and making inferences in their deep-reasoning answers (Watanabe et al., 2023). The most frequent type of questioning involves closed response in which the answers are single-word answers whereas open ended questioning is the least frequently asked type of question (Buckley et al., 2023). Students responded only 14% of the time to open-responsive questions as compared to 32% with one -word responses (Buckley et al., 2023).

In order to assist students in learning how to answer questions, teachers can utilize instructive lessons of upward or downward scaffolding for more accurate utterance responses (Deshmukh et al., 2022). The strategy of verbal scaffolding in upward or downward responses allows the adult to discuss accurate or inaccurate utterances by adjusting their follow-up replies (Lang, Speech, & Hearing, 2022). The upward scaffold challenges the answer by prompting further reasoning and predicting whereas the downward scaffold simplifies the questions and provides more support for a child to find a correct answer (Pentimonti & Justice, 2010 as cited in Buckley, Martinez & Ozdemir, 2023). Therefore, a young learner needs opportunities to think aloud and discuss their observations and understanding of their new knowledge with the support of adults conversing in longer conversations in which he can have multi-turns to reflect and analyze their answers (Cabell et al., 2015 as cited in Deshmukh et al., 2022).

Method

For a period of one week, I worked with twelve kindergarten students to read, study, experiment and discuss questions about water resistance and penguins. The purpose was to ask and answer questions based on prior knowledge and then try out ideas about water resistance properties. The process involved asking and revising queries on predictions, results and outcomes. The participants had consent from their guardians to work with me utilizing one-on-one instruction, but I also read the materials about penguins to the other students who were not participants. In addition, I had permission from the school and the district administration to conduct the research during the school day since I was a classroom volunteer.

The definition of an action plan is to study how to improve students' abilities by evaluating teaching strategies in order to develop solutions for effective teaching. This plan was based on five essential steps as defined by Mertler (2024).

1. Identification of a problem
2. Gather relevant data
3. Interpret findings
4. Act on evidence
5. Evaluate results

During the five sessions, I asked a variety of questions including open and closed responses, as well as, literal, inferential, predictive, personal, evaluative and reflective which allowed each student to respond with one word to multiple sentences answers. In turn, I encouraged students to ask me questions in regards to the text, experiment and observations. In addition, I asked them what else they wanted to know or learn even if it wasn't related to the specific topic.

Action Plan

My daily lessons were designed to gather data for five consecutive days in which modeling and teaching questioning strategies were engaged in each session. Each session concentrated on the following key concepts and activities: prior knowledge about rain and water, introducing and reading a nonfiction story about penguins, taking turns reading to practice vocabulary, and asking a series of questions about the properties of water resistance. The students and I then conducted experiments based on our questions to observe the effects on water on different materials. Then we discussed our observations and findings. Finally, each child wrote and drew pictures about what we learned in booklets that they could take home to read to their families. During each lesson both the student and I asked and answered multiple questions in which I recorded the responses on sticky notes and then transferred them to a spreadsheet (see Table 1).

Day 1

As a classroom volunteer, I initiated a conversation with each student about the weather outside. I intentionally chose a topic that I knew the majority of students had prior knowledge. I asked the child to observe the sky from the classroom window and then describe it to me. This is followed-up with the following questions:

What is the weather outside today?
How do you know?
What would it look like if it wasn't sunny?
What would you wear if it was raining?
What is the job of your coat?
What would happen if you didn't wear a coat?
Describe your coat?

Table 1. Multiple Questions and Reponses of Day 1

Student	**Literal**	**Evidence**	**Inferential**	**Personal**	**Evaluative**	**Personal**	**Literal**
Responses (students are identified by number)	What is the weather outside today?	How do you know?	What would it look like if it wasn't sunny?	What would you wear if it was raining?	What is the job of the coat?	What would happen if you didn't wear your coat?	Describe it
1	Sunny	Light out	Storm	Jacket	To keep you dry	You would get wet	
2	sunny		Foggy, wet	Jacket	To keep you dry	Wet like when you get wet jumping in puddles or when you take a bath	
3	Sunny	By looking at the sky	Rainy	Jacket	To keep dry	Wet like in a bathtub	

Student Responses (students are identified by number)	Literal What is the weather outside today?	Evidence How do you know?	Inferential What would it look like if it wasn't sunny?	Personal What would you wear if it was raining?	Evaluative What is the job of the coat?	Personal What would happen if you didn't wear your coat?	Literal Describe it
4	Sunny	No clouds	Any other kind of weather windy or rainy	Wear raincoat	Stay dry	Get wet	orange
5	Sunny	See light traveling on buildings	Storm raining	Rain coat, rainboots	dry	Soaking wet	Light one
6	sunny	Blue sky	Might rain Thunderstorm clouds	Rain coat	Keep your clothes dry	wet	Purple with a little pink dots
7	clear	Blue sky, no clouds	If it is cloudy, darker Rain little circles of water	Rain jacket	Keep you dry	cold	Flowers, pink and white
8	Sunny	Not even a single cloud in the sky	Clouds covering the sky- raining	Raincoat, rain boots	To keep you dry	Totally soaked/hard rain	Exactly blue gray with a hood
9	Sunny	Sky is blue Not very much clouds	Rainy-kinda of gray Darkish Drops of rain	Coat-light Not actually raincoat	Keep rain off of you	Clothes wet	Black and red
10	Sunny	See the sun	Raining Water falling down from the clouds	Raincoat	To keep warm and not wet	wet	Fuzzy warm coat blue
11	Sunny	Cause sunny and bright outside	Rain falling out of sky	Jacket/raincoat	Keep from not getting wet	Get wet	Pink with rainbow colors hoodie
12	Sunny	Grass is dry Not lots of clouds	Raining Water drops	Raincoat Rain hat Rain boots Sometimes	It keeps me safe from rain	Wet	Yellow rain coat Rain boots are black

Student Responses (students are identified by number)	Literal	Evidence	Inferential	Personal	Evaluative	Personal	Literal
	What is the weather outside today?	How do you know?	What would it look like if it wasn't sunny?	What would you wear if it was raining?	What is the job of the coat?	What would happen if you didn't wear your coat?	Describe it
				rain pants			Rain hat is yellow

As each student responded to the questions, I wrote the answers on sticky notes. Next, I took a photo of each child wearing his coat, so that I could include this at the end of lessons in their own booklets. As we concluded our first session, I read from the National Geographic Kids book, Weather (Rattini, 2013). With the kindergarten student sitting next to me, I showed the title of the book followed by reading the titles of the chapters of the Table of Contents. I explained that I was only going to read a couple of pages of this nonfiction book because I wanted to learn about two topics: *What is Weather? and Clouds*. The new vocabulary word '*droplet'* was defined and we discussed what it meant.

Day 2

During this session I interviewed each student about prior knowledge about pets and animal coverings.

Do you own a pet?
What kind of pet?
What covers your pet?
Does it like water?
What covers you?

I recorded their responses on sticky notes and transferred them to a table (see Table 2).

Table 2. Multiple Questions and Reponses of Day 2

Students	What covers your pet	Does it like water	What covers you	What cover penguins	Do feathers get wet	Why	What does waterproof mean
1	Bird/feathers		skin	Wing feathers	No	Won't fly correctly They need to fly higher	

Students	What covers your pet	Does it like water	What covers you	What cover penguins	Do feathers get wet	Why	What does waterproof mean
2	Dog/fur	Likes water	skin	Feathers	Yes	protection	It can get it wet, it stays safe
3	Kitten/fur	No, it might get soaking wet	skin	Feathers	Yes		Don't get wet
4	Dog/fur	Doesn't like rain	skin	Feathers	Yes		Proof for water
5	Dog/fur	No, doesn't like water	skin	Feathers	Yes		Allowed to go in water
6	Goldfish/scales	yes	skin	Feathers	Yes		Not get wet
7	Cats/fur	Doesn't mind rain	skin	Feathers			Get in water Not waterproof like playdog cant get wet
8	Cats/fur Salt and Pepper	Indoor cats Sometimes get wet	skin	Feathers	Yes		Waterproof doesn't get wet by water
9	Dog/hair	Stay inside Wouldn't want to go on walk	skin	Feathers			That you go in water, it won't make you cold
10	Dog/fuzz	She doesn't like getting wet-not swimming	skin	Wings	Yes		Allowed in water
11	Dog/fluff	Likes the rain	skin				Jump in water feel water on you
12	Absent						

Next, I read a shared read aloud, We Both Read: Penguins (McKay, 2024), which is designed with two text sections. One page is for an adult reader and the opposite page for a beginner reader. However, this book was difficult for a kindergartner to read. Therefore, I selected three pages of the nonfiction books to highlight characteristics and features of penguins to read aloud. We noticed the illustrations on each page of the black and white penguins.

Before Reading

I asked each student these questions: “What covers the penguins’ bodies”?, “Do penguins get wet”?, “What does waterproof mean”? The first page I read was titled, Bird? Fish? Insect? Mammals? As I read the text, I paused and reread the sentence, “Their uniquely evolved wings are covered in scale-like feathers” (McKay 2024). I modeled a think-aloud and said, I found the answer to our first question, “What covers the penguins’ bodies”? “What did the story tell us”? Each child was able to respond with the answer, “feathers”. I finished reading that page and then turned to the chapter, Feet and Feathers. On page 18 I shared the text that explained that “the penguins are covered in tightly packed outer feathers which are coated with a type of oil to make them waterproof” (McKay 2024).

During Reading

I asked each student if they learned if the penguins get wet? Based on their response, I would scaffold the next question to be easier or more difficult. The easier question would be to review the sentence “that penguins spend 75% of their lives in the water.” And then, I asked again, “Do you think that the penguins would get wet”? The upward scaffold question for children that answered correctly, *“Do the feathers get wet?”, “Why or why not?”* Next, I would ask each individual, *“What covers the feathers to make them waterproof”?* The scaffolding questions based on the responses were: Downward*: What covers the feathers?,* Upward: *Where does the oil come from?*

After Reading

Finally, I would ask them to explain what waterproof means*?* Then, I would ask if they could give me an example of something that is waterproof? As part of our discussion, I introduced the concepts of repel and resist. I shared that tomorrow we would experiment with things that were waterproof. As we concluded this lesson, I asked if the kindergartners had questions that needed to be answered (see Table 3).

Table 3. Kindergartners’ Questions needed to be Answered

Student by number	Question to be answered
1.	I want to learn more about eagles.
2.	How do they fly? How do they swim?

3.	No question
4.	How are feathers made? And does the liquid on feather keep them warm?
5.	Will the feathers stay dry?
6.	I wonder how they stay cool without their fur? How do the babies get their food?
7.	I wonder how waterproof it is?
8.	Is waterproof and water resistance the same? What if penguins didn't have feathers? How many kinds of penguins are there?
9.	No question
10.	How (do) they (feathers) fall down (fuzzy stuff)?
11.	absent
12.	How do they get wet?

Materials for Experiment

Two bowls for water

Spray bottle with water

Paper towels

Dried sponges

Feathers

Feathers covered with oil

Droppers

Tissue paper

Student form labeled with headings on two separate sections

Repel Absorb

Observation recording form

Post it notes

Day 3 - Experiment/Lesson

Are bird feathers waterproof?

Compare Absorb and Repel/Resist

Procedures:

Review meaning of waterproof

Review what we read about penguin feathers

Lesson:

Ask student to define absorb and resist/repel

Record observations, responses and questions on sticky notes for each scientist for the following predictions. Table 4 shows student predictions for each of these materials and their responses to word meanings.

Predict If paper towels will repel water

Predict if sponge will repel water

Predict if feathers will repel water

Select a paper towel and predict if it will absorb/repel

Spray water on it.

Observe what happens

Describe it

Decide if it absorbs or resists/repels water.

Put on the recording page under the correct response.

Select a feather and predict what will happen when you drop water on it.

Will the water droplet absorb or resist/repel?

Use a dropper and drop water on it.

Observe what happens

Describe it

Decide if it absorbs or repels water.

Put the feather on the recording page labeled the correct response.

Select a sponge and predict which it will do absorb or resist/repel

Pour water from a bottle inside a bowl on a sponge.

Observe what happens.

Describe it.

Decide if it absorbs or repels water.

Put on the recording page under the correct response.

Select a white (oily) feather and predict which it will do absorb or resist/repel

Use a dropper and drop water on it.

Observe what happens.

Describe it.

Decide if it absorbs or resists/repels water.

Put on the recording sheet under the correct response.

Table 4 Experiment Predictions from Activities

Students	What does waterproof mean? Review	What do you remember about penguin feathers?	What does absorb mean?	Prediction Paper Towel waterproof	Prediction Sponge WP	Prediction Feather WP
1	If my bird gets wet, it will fall	thunder wings	Did not know			
2	When it gets water on it	Did not respond	No	No, gets wet might rip	yes might get wet	Oily, soft resist
3	Doesn't get wet	Oil on it	Comes out	Wp yes Suck in water absorbs	Wp yes Soaks in absorbs	No wp repel Drop off
4	Stuff is approved for water	Oil	Eats something turns into something else	Not wp Touch this water soaked up Might rip	Yes absorb	Furry, soft Oily Absorb
5	Allowed to go in water	Did not know	Look at something, shouldn't touch	No absorb	No absorb	Repel
6	Waterproof means not getting wet	Penguin feathers oil	Absorb Did not know	Yes, absorb Suck in	Yes Suck in absorb	Doesn't like still water Repel
7.	Waterproof-go in water	Did not respond	Did not know	Maybe soak up water	absorb waterproof like pt, absorb	Not waterproof Oil
8	Water resistance , don't get wet	oil	Pulled towards it	No absorb	No absorb	Yes, Soft sticky oil repel
9.	If you go into water, you want get wet	no	Like if you eats something you absorb	Not get wet	Waterproof suck water	Maybe repel

Students	What does waterproof mean? Review	What do you remember about penguin feathers?	What does absorb mean?	Prediction Paper Towel waterproof	Prediction Sponge WP	Prediction Feather WP
10	Allowed in water	fuzz	Did not know	Sure wp repel	Yes repel	No fuzz come off repel
11	Resisted	oil	Did not know	Won't get wet	repel	Yes, oily and water will fall off
12	Won't get wet	Did not respond	Did not know	Yes Did not know .absorb	Yes Did not know absorb	No Did not know absorb

As we observed our recording page (Table 5) showing the results of the experiment with the paper towel, two feathers and sponge, I asked each one "What did we find out?" After a discussion about the observations and the findings, I wondered "If a bird feather gets wet, then water will…", "Why"? I wrote a conclusion statement based on their answer. Table 6 shows the student responses.

Table 5 Experiment Results

Students	Paper Towel Observation	Color Feather Observation	Sponge Observation	White Feather Observation
1	Tissue suck	Water dropped off	Sucked	Water fell off
2	Sucked in, not wp	Bubbled dropped off	Sucked in absorbed	Exactly right other feather, repelled
3	Water sucked in	Repelled	Absorbed	Resistance
4	Got into it absorbed	Bubbles, drops	Water soaked in	Water resisted
5	Absorbing	Went off resisted repelled	Went inside Squishy	Went off
6	Absorbed, liquid sucked in	Rolled off droplets repelled	Absorbs	Repels
7	Soaked up	Sitting on it water droplets, sliding off, Resisting bc oil	Water scooped up Absorbed	Just like other feather
8	Soaked up	Water stayed on Water droplet	absorbed	Like other feather water dropped off
9	Wet , water got inside it	Water went off	absorbed	Drops. Made drops went off
10	Soaked in	Made bubbles	Soaked in	Like other feather resisted
11	Soaked up	Drops of water	Soaked in	fall off
12	Sucked in	Slid off	Went inside	Slid off

Table 6. Conclusion Responses

Student Number	Response
1.	If a feather gets wet, then the water will come off.
2.	If a feather gets wet, then the water will fall off.
3.	If a feather gets wet, then the water will drip off.
4.	If a feather gets wet, then the water will turn to bubbles.
5.	If a feather gets wet, then the water will repel.
6.	If a feather gets wet, then the water will repel because of the oil on it.
7.	If a feather gets wet, then the water will repel off.
8.	If a feather gets wet, then the water will slide off and be water resistant.
9.	If a feather gets wet, then the water will be on and then fall off.
10.	If a feather gets wet, then the water will push off.
11.	absent
12.	If a feather gets wet, then the water will repel because of the oil.

Day 4

Next, I read a shared read aloud, We Both Read: Penguins (McKay, 2024), which is designed with two text sections. One section is more difficult informational text about penguins that the adult will read and on the same page, age-appropriate text for a beginner reader. With support kindergarteners can read the large predictable text. We noticed the illustrations on each page of the black and white penguins. We learned that penguins are excellent swimmers. Next, we discovered that penguin chicks' new feathers are waterproof for swimming. I asked each student to recall "What does waterproof means?"

As we reflected on our findings and the meaning of waterproof, we discussed if our own questions had been answered. I reviewed the question that each one posed on Day 2. We decided if the question had been answered by one of the books or during the experiment. I recorded the answer that each student reported as the finding of their inquiry. The next step was to create a booklet for each student so that the individual findings and results of the experiments and new knowledge could be recorded. Utilizing a six-page book format, each page posed a question heading followed by the students' answers.

These are the headings for each page for the booklet titled *Penguins!* I recorded the answers that each child shared with me using their own words to explain what should be written in response to the headings.

F	Find out facts
A	Ask me more
C	Connections to you
T	Tell me more
S	Share Something You Learned

Day 5

As I met with each student, I shared their booklet with them and inquired if there were any other interesting facts that they wanted to include in the book. Each student illustrated a drawing of their favorite penguin for the cover of the booklet. I collected their drawings and rough copy of the booklet in order that I could finish each one at home. A few days later I presented each participant with their own booklet and we read it together. Finally, each scientist took home their Penguin book to share and read to their families. Below are examples from one student's Penguin book. (Figure 1-4)

Figure 1. First Example of Penguin Book

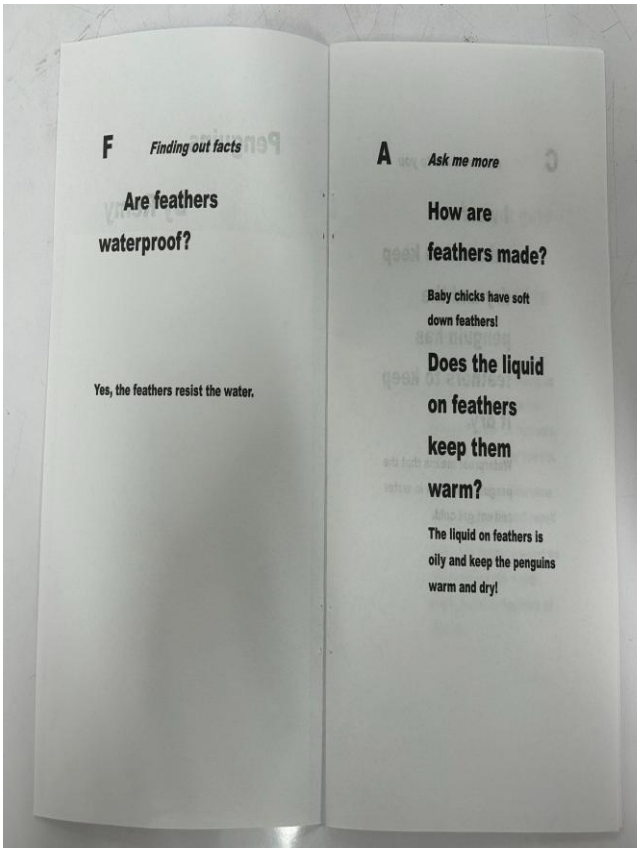

Figure 2. Second Example of Penguin Book

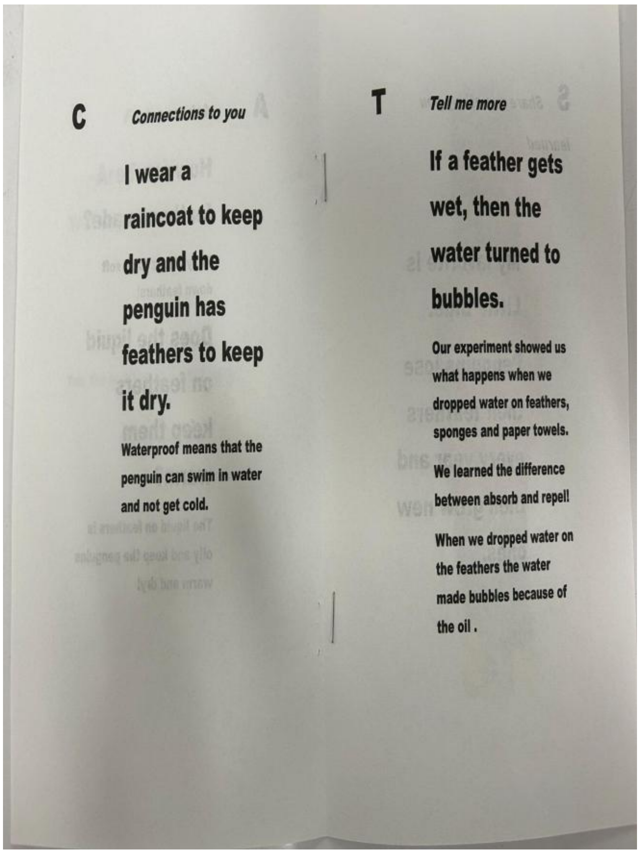

Figure 3. Third Example of Penguin Book

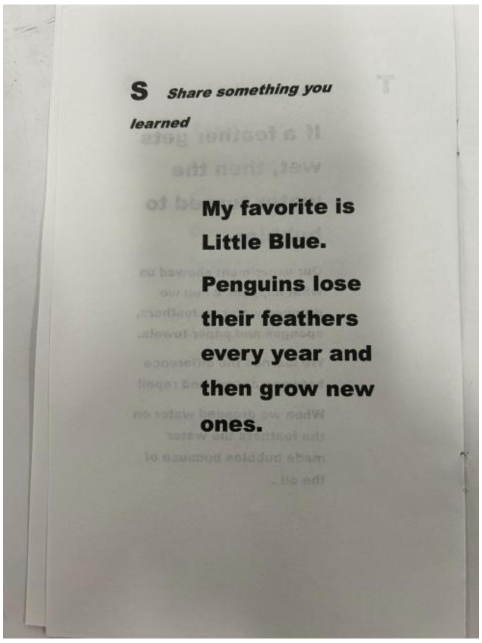

Figure 4. Fourth Example of Penguin Book

Data Collection and Analysis

During the week of data collection, I documented the children's responses to all the questions in order to determine how the action research question was answered.

> *Q. When you teach explicit questioning techniques to explore science, will students transfer that knowledge in their verbal exchanges as they ask their own questions and answer with improved accuracy and detail in discussions?*

I collected their questions and answers on sticky notes and then recorded the data on spreadsheets each day. I allowed each child to discuss and think out loud in order to process their observations and their findings. The majority of my questions sought answers to the six different types of questions which included literal, inferential, evaluative, personal response, prediction and reflective. Most of my questions began with the word '*what*' questions, but also included personal response and reflective style inquiries. Students' questions were mostly all literal style seeking specific answers to their own questions about penguins.

Discussion and Conclusion

During this study I was modeling asking six different styles questions so that I could determine if my action research question could be answered. The participants' questions were mostly literal questions with a few exceptions. One student asked an inferential question, "What if penguins didn't have feathers?" Two students asked "I wonder" style inquiries which would provoke longer discussion in answering them. The majority of the questions began with *'how'* and sought explanations or one correct answer. I discovered that the kindergarteners' ability to generate questions improved over the five days as well as answering the questions by conversing in longer responses than just one-word utterances. As I tallied their replies, I determined that most students answered in longer phrases in an attempt to give a more detailed and complete response. As we discussed what FACTS we wanted to include in their booklets, the students expressed their thoughts and answers in complete sentences. When I was transcribing their answers, I used their own words and expressions.

First, I believe that during the five sessions, the children did improve in both asking and answering the questions. By asking a variety of questions, the students became more comfortable in answering with more details. As I scaffolded the questions based on their answers, I supported each child's understanding and helped them answer accurately the majority of the time. By giving time to each participant to discuss their thoughts and interests, our work sessions were meaningful. In addition, I respected that some of their questions did not involve the study of penguins' feathers being waterproof, but something else that they needed or wanted to know. One student wanted to learn more about eagles and some wanted more information about penguins' babies and eating habits. I noticed that the students' listening ability improved as we read the shared stories together. When I paused while reading and asked a question concerning the text, the student stayed engaged and attentive. Their comprehension improved as their answers to all the questions became more accurate and they were able to give evidence or personal reflection. The advantage that I had as a classroom volunteer was that I could patiently wait for each student to express their responses or answer or while the student experimented dropping water on the feathers as many times as needed to observe what was happening. Both of us could take as many turns as necessary to discuss our findings. Instead of just a couple of turns to converse, each child had unlimited time, since I was not responsible for the rest of the class.

Recommendations

At the conclusion of these lessons, I realized that having a positive one-on-one relationship with the kindergarteners prior to our week of the action research, helped the students share their responses with me, as they had previously interacted with me. In order to do such in depth reading, listening, discussing and recording of individuals, untimed periods of time are essential. By using a trained volunteer, I was not constrained by time limits. Some students needed more time than others. If the window of time for the research had been longer, I think I would have seen more attempts of different styles of questions by the students. Over time the students might have asked more evaluative and reflective style questions.

Finally, I understand that classroom teachers give their best instruction each day, but do not have the luxury of unlimited time to spend with each child for more than just a couple of minutes. That is why I would highly recommend forming relationships with retired teachers or older adults who enjoy working one-on-one with students and who love to share their knowledge. The students love the attention and time that this volunteer can spend reading and talking to each child. I am confident that a classroom teacher can model and teach all the different styles of questions, but utilizing a classroom volunteer is instrumental in listening and talking with each student to improve individual opportunities to question and discuss new learning and concepts. In conclusion, I believe that the action plan gave beneficial results in transferring improved questioning skills and verbal exchanges for the participants of the study.

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SECTION II

Chapter 5 - Teaching and Learning Together: How a Preservice Methods Course Helped Students and Their Instructor Increase Their Understandings of the Science of Reading

Dr. Kristen A. Poindexter

Chapter Highlights

- Explicit teaching of science of reading concepts can improve preservice teacher knowledge and use.
- Professional growth both on the part of the instructor and preservice teachers occurred during this 8-week course covering science of reading content.
- Preservice teachers experienced hands-on lessons and demonstrations of science of reading activities, modeled for them by their instructor and kindergarten students.

Introduction

In May 2023, the Indiana legislature introduced legislation requiring schools to adopt curricular materials that are aligned with the science of reading. It also requires prekindergarten through fifth grade teachers graduating after June 2025 to earn a new literacy endorsement. In addition, all colleges and universities by 2025, must include a science of reading aligned course in their teacher preparation programs (Appleton, 2023). As both a practicing classroom teacher and an adjunct professor, I am affected in both of my teaching roles by this new legislation.

As a practicing classroom teacher, I was watching the legislation take shape as it had already done in many other states. To prepare for the shift I knew would come, I began reading online articles, blog posts, and professional books and literature designed to help teachers make the shift from whole or balanced literacy practices to science of reading focused practices. It was overwhelming! I also attended professional development sessions within my school district and those offered by our curriculum program. At the same time this legislation was being enacted, I was asked to teach the "Literacy in the Early Childhood Classroom" course at the college where I am an adjunct professor, during the Spring 2025 semester. The course content and outline would be developed for me, however, I would need to teach and model many of the skills in the course from my lens as a kindergarten teacher. The course outline followed the recommendation of the state legislature and included the "big 5" areas in which students needed to learn to help them become successful readers; phonemic awareness, phonics, comprehension, fluency, and vocabulary.

With the new legislation, I would need to take the coursework to add the literacy endorsement to my teaching license. The coursework required 80 hours of learning and journal entry assignments along with a certification exam. I knew that if I wanted to best prepare myself for teaching both my kindergarten students and my college students, I would need to take this course along with reading thoroughly through my teacher manuals. Scarborough's (2001) Reading Rope (see Figure 1) was the guide of the coursework and introduced in the beginning of nearly every book, article, and professional development course I read or attended. The reading rope demonstrates how each of the tenets of language comprehension and word reading are woven together to help develop skilled readers and writers.

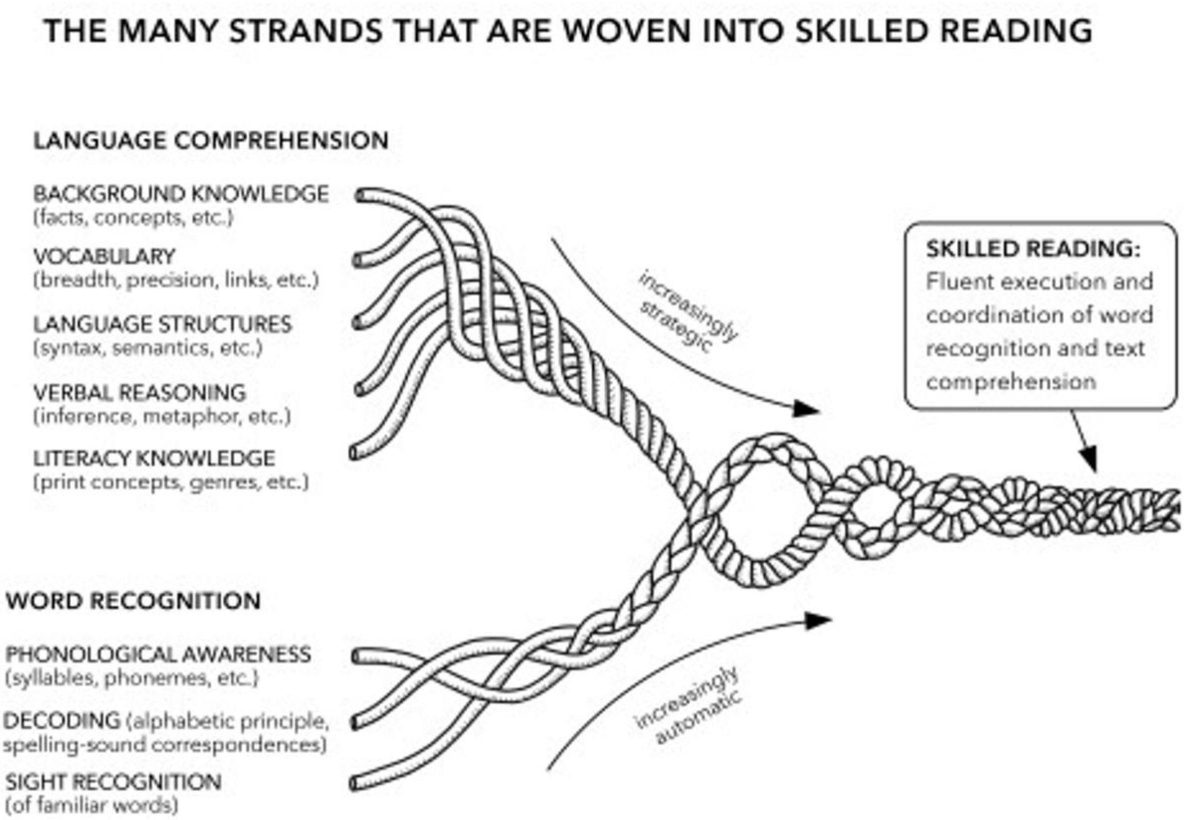

Figure 1. Scarborough's Reading Rope Scarborough, (2001)

Reframing the way I needed to teach my kindergarten students became my focus as the kindergarten school year would begin before my college course. As I read and learned with my kindergarten students, I felt more comfortable. It became clear that all of the ways I taught literacy in the past were not wrong, we needed to change the order and emphasis of many things, but there were lots of great things already happening. Throughout the entire first semester of the 2024-2025 school year, I took short videos of my teaching and my students practicing the new skills so that I could see if how I was instructing them was effective, but also so that when I had college students learning about the same strategies, I could show them what they looked like in practice.

As a lifelong learner, I have learned that I have to try out a strategy many times before I am able to teach that strategy to others. I felt confident by the time the course began in January that I would be able to share lots of literacy activities and strategies with my preservice teachers, however, there were so many interesting words and strategies that were new to me, I was not sure if I could properly instruct pre-service teachers about them. I decided that the best way for me to learn how to instruct pre-service teachers was to learn a bit ahead of them and also along with them. I stayed one course module ahead of where my students were and ready every article and textbook reading they were required to. I wanted to learn alongside my students and also instruct them in strategies, tools, tips, and activities that would help them teach their future students. I wondered if we could learn together by bringing our different lenses; preservice teachers, kindergarten teacher, and adjunct instructor, and leave the course feeling empowered to confidently teach our students. I decided that an action research study would be the best way for me to study my own learning and to capture how my preservice teachers were learning as well. Given that my preservice teachers and I all have growth to make in learning about the science of reading, I guided this work with the following research questions:

1. In what ways can practicing classroom teachers and preservice teachers learn about the science of reading and how will they show growth in their learning?
2. Does the explicit teaching and modeling of science of reading concepts and strategies improve preservice teacher knowledge?

Literature

There are currently many professional books written for teachers who would like to learn more about the implementation of the science of reading strategies in their classrooms and schools, however, when it comes to colleges and universities, the guidance on what should be included in those programs is guided by the legislation passed by the Indiana House of Representatives. The legislation includes the following guidance as shared by the Indiana Department of Education, "House Enrolled Act (1558) (2023) adds science of reading as a required component of educator preparation and program accountability measures. Educator Preparation Providers (EPPs) preparing elementary, early childhood, and special education teacher candidates shall include content within the curriculum that is aligned to the science of reading. This additional requirement applies to any program completer who will be licensed in elementary, early childhood, and special education and teaching kindergarten through fifth grade. Science of reading shall be included in their plan of study not later than July 1, 2024. EPPs shall also prepare teacher candidates or program participants to obtain the literacy endorsement required under IC 20-28-5-19.7. Science of reading is defined by a new section added to IC 20-18-2. Beginning July 1, 2024, the Indiana Department of Education will begin reviewing EPPs to ensure alignment of program requirements to science of reading preparation" (Indiana Department of Education, 2023). Further down in the guide, the more specific details are given as to what components should be included in college and university level coursework, “As defined by Indiana Code (IC) 20-18-2-17.5, "science of reading" means a vast, interdisciplinary body of scientifically-based research that requires the explicit, systematic inclusion of the following five essential components: phonemic awareness, phonics, fluency, vocabulary, and comprehension. Additionally, two more components are included in the guidance:

> Coursework about the science of reading is supported by evidence that informs how proficient reading and writing develop, why some students have difficulty with reading and writing; and how to effectively assess and teach reading and writing to improve outcomes for all students.
>
> Introduced strategies have a demonstrated record of success, and when implemented, leads to increased student competency in the areas of: phonemic awareness, phonics, reading fluency, vocabulary development, oral language skills, reading comprehension, and writing and spelling (Indiana Department of Education, 2023).

This is the current guidance given to colleges and universities to structure their science of reading coursework. It aligns with the work that inservice teachers are doing in their classrooms and guided the structure of the early literacy course that I taught. Given that this is the guidance that the Indiana Department of Education provided to schools, colleges and universities, I was interested to find out how the early literacy course I would be teaching would be structured and how each of these elements would be taught. I also wondered how my explicit teaching of science of reading concepts and strategies would improve preservice teacher knowledge.

Method

As I am a practicing classroom educator and adjunct professor, I chose to use an action research study method to determine my actions as a teacher on my preservice teacher's growth and my own growth in our use and understanding of science of reading concepts and strategies during our 8-week course. This study was conducted using action research methods as defined by Yin (2016), using five features of action research:

1. “Studying the meaning of people’s lives, in their real-world roles.
2. Representing the views and perspectives of the people (participants) in a study.
3. Explicitly attending to and accounting for real-world contextual conditions.

4. Contributing insights from existing or new concepts that may help to explain social behavior and thinking.
5. Acknowledging the potential relevance of multiple sources of evidence rather than relying on a single source alone."

Action Research Approach

During the teaching of the early literacy course, I wanted to collect information from students in the course who consented to do so and also wanted to collect my own learning and thoughts as the instructor of the course. As the course was developed and designed for me, I had to follow the sequence I was given, however, I was able to add in additional information as needed. The course is being taught at a community college in Indiana and the developers of the course wanted to ensure that all students taking the course, no matter which campus, received the same information. I collected information from one student who gave consent in a pre and post survey along with my own notes that I took during the course about the ways in which my students were learning and any new learning I had. I will be using the following research questions to guide my inquiry:

1. In what ways can practicing classroom teachers and preservice teachers learn about the science of reading and how will they show growth in their learning?
2. Does the explicit teaching and modeling of science of reading concepts and strategies improve preservice teacher knowledge?

Action Plan

The structure of the course contained 16 modules and was housed in an online learning platform. As the course was taught for only 8 weeks, we worked through 2 modules each week and during our once weekly in-person meeting (see Table 1). During in-person meetings, I would teach the course content via lecture and slides that showed examples of students working with materials in classrooms. We also had in class course readings that we discussed together, modeling of lesson teaching, pictures and examples from my kindergarten classroom, and time when students would share their lessons or would teach their lessons. There were four students in the course and two joined me in the classroom in-person and two students joined via online video communications due to their proximity to the campus location. Generally, the two students in person would partner together for work and the two students online would be partners for in class work that required peer feedback and teaching partners. During the course, students were required to work with a four to eight year-old child several times. Microteaching experiences were included as part of the coursework; students would learn about a teaching strategy, watch me model it in class, ask questions and then write their own lessons. Lessons were role-played in class between students and peer and instructor feedback was given before students used the lessons with children.

Table 1.Course Modules and Topics

Week 1: Modules 1 and 2 Topics: Identifying the reading crisis and national recommendations, learning about MTSS and other systems of support to help students
Week 2: Modules 3 and 4 Topics: Goals, benefits, and uses of assessment, introducing the simple view of reading and the reading rope
Week 3: Modules 5 and 6 Topics: Types of instruction and preparing the classroom environment, oral language development
Week 4: Modules 7 and 8 Topics: Phonemic awareness, print awareness and alphabet knowledge
Week 5: Modules 9 and 10 Topics: Putting knowledge into practice/microteaching experience and phonics and spelling
Week 6: Modules 11 and 12 Topics: Fluency and vocabulary
Week 7: Modules 13 and 14 Topics: Listening comprehension and reading comprehension and putting knowledge into practice/microteaching experience
Week 8: Modules 15 and 16: Topics: Writing and putting knowledge into practice/microteaching

Data Collection and Analysis

My initial plan for this study was to measure the growth of my students surrounding their pre and post knowledge of science of reading concepts, however, as I began looking into the course material through my instructor and teacher lens, I realized that I also had growing to do. To capture my own learning and reflections, I wrote them down in the same Steno notebook that I use to plan out each week of in class work. This helped me keep track of what the students were learning and my own learning about the same content or to write down examples of what I thought would be helpful for students to see or hear from my classroom teacher lens. I find it helpful to keep my notes from course teaching to course teaching so that I can revisit them each time I teach the course again to help remember what worked, what did not work, and what changes I made.

I developed a survey for my preservice teachers that addressed their understanding of each of the "big 5" areas that make up the science of reading (phonemic awareness, phonics, fluency, vocabulary, and comprehension). I also looked at the course modules and developed questions that asked students about assessment, differentiation, and critical thinking. I wanted to survey to measure growth of understanding over the 8 week course, however, knowing how much coursework my students were required to complete during the course, I asked participating students to complete only a pre and post survey. The questions on the survey are as follows:

Foundational Skills:

What is the Science of Reading? How would you define it in your own words?

How would you explain the concept of phonemic awareness and how would you assess a student's level in this area?

What are the key phonics rules you would prioritize teaching beginning readers, and how would you systematically introduce them?

How do you plan to develop students' reading fluency, including accuracy, rate, and expression?

How do you define phonemic awareness? What are skills that students would learn in this area?

How do you define phonics? What are skills that students would learn in this area?

Vocabulary Development:

What strategies will you use to teach vocabulary words effectively, including pre-teaching key terms before reading?

How would you incorporate rich vocabulary instruction into your lessons to support comprehension?

Comprehension Strategies:

How would you teach students to use comprehension strategies like making predictions and questioning while reading?

How do you plan to address different reading levels within your classroom to ensure all students can access text appropriately?

Assessment and Differentiation:

Can you describe a specific lesson plan that incorporates the principles of the science of reading, including explicit instruction and systematic practice?

Critical Thinking:

What are some potential challenges in implementing science of reading practices in a classroom, and how would you address them?

How would you stay updated on current research regarding the science of reading to inform your teaching practices?

Results

At the completion of this course, I found that my preservice teacher grew in their understanding of the science of reading and was able to better articulate student and teacher actions when responding on the survey and during in class discussions. I found that I also grew as an instructor in my own knowledge of the science of reading, however, most of the growth I made during this course ended up being related to taking my kindergarten teacher practices and turning them into lessons that would not only teach my preservice teachers, but model for them how the science of reading looks in a classroom in practice. I also found that I had quite a bit of background knowledge, more so than I thought before teaching this course. The following research questions guided this action research study:

RQ1: In what ways can practicing classroom teachers and preservice teachers learn *about the science of reading and how will they show growth in their learning?*

RQ2: Does the explicit teaching and modeling of science of reading concepts and strategies improve preservice teacher knowledge?

Table 2 shows the responses given by one preservice teacher in this course. The pre-survey was given to students at the beginning of the course, before any course material had been taught or shared with students. Students were not yet able to view the online portion of the course or topics we would cover other than what was listed in the course catalog. Table 3 shares my notes as the instructor that were recorded while planning for the course each week and reflections I noted after each week was completed.

Table 2. Preservice Teacher Survey Pre/Post Responses

Question	Pre Survey Response	Post Survey Response
What is the Science of Reading? How would you define it in your own words?	It's researched based on how kids learn how to read the best, like phonemic awareness.	Research of children learning how to read.
How would you explain the concept of phonemic awareness and how would you assess a student's level in this area?	I teach phonemic awareness through Zoo-Phonics. I assess this individually in the fall and spring during assessments. I test to see if they know their letter sounds, and whether or not they can recognize their upper and lower case letters.	Phonemic awareness is the recognition of sounds and phonemes. I would use the DIBELs or PalsK
What are the key phonics rules you would prioritize teaching beginning readers, and how would you systematically introduce them?	start with uppercase letters, then lower case, I also would use sight words.	I would start with segmentation by breaking down the words c/a/t and sound each letter out.
How do you plan to develop students' reading fluency, including accuracy, rate, and expression?	Through Zoo-phonics	I think the more exposure the better. Picking readers that are at their level will help generate interest and therefore it easier to work with these skills.
How do you define Phonemic	Being able to tell that there are 3	It is the recognition of sounds,

Question	Pre Survey Response	Post Survey Response
Awareness? What are skills that students would learn in this area?	sounds in the word c-a-t. They are learning how to spell and learning how to read.	students will learn how to isolate-blend-segmentation-and finally manipulation.
How do you define Phonics? What are skills that students would learn in this area?	I would define it as letter sounds.	a method of teaching people to read by sounds with letters or groups of letters in an alphabetic writing system.
What strategies will you use to teach vocabulary words effectively, including pre-teaching key terms before reading?	I use zoo-phonics activities and I use sight words, along with books and hands on activities like tracing a letter in paint or salt.	Prior to reading, create a word bank of the vocabulary that my students will see throughout the unit, as we work with other subjects those new words will be also added to our list.
How would you teach students to use comprehension strategies like making predictions, visualizing, and questioning while reading?	Taste test Tuesday. We use a white board and a food item that starts with the letter of the week. We make predictions and we write our predictions on the whiteboard.	By asking questions prior knowledge on the subject or topic. using asking open ended questions for critical thinking.
How do you plan to address different reading levels within your classroom to ensure all students can access text appropriately?	Zoo-phonics has its on curriculum and lesson plans that in my opinion align with the science of reading	I think all of the lesson plans do incorporate the science of reading. I think our Final Project put everything that we learned into practice in this course.
What are some potential challenges in implementing science of reading practices in a classroom, and how would you address them?	Kids not wanting to participate in reading. I would make hands on activities that are fun and engaging that teach them letter sounds and to recognize letters in a fun way	I think the challenge is that we just keep to one system and move from there. If the research has already been done and it's working, the important thing is to stick to that, the problem is when the hierarchy in education decides to change things around, without giving it a chance to work.
How would you stay updated on current research regarding the	I wouldn't.	Reading books, and taking courses to help me . I now know

Question	Pre Survey Response	Post Survey Response
science of reading to inform your teaching practices?		more through this course and it makes sense.

Table 3. Instructor Module Notes and Reflections

Modules	Instructor notes
Modules 1 and 2	Module 1: This module introduces the overview of the course and how it will flow, not much to add here except we will need to have a pre instruction discussion about the science of reading, its foundations, why they are taking this course, how it will benefit them and their teaching practices. Module 2: Introducing MTSS, talk about examples of how this is done in my building, address how this has to be a solid system or it will not be effective in student success.
Modules 3 and 4	Module 3: Begin with debrief of "Hard Words" podcast, what are thoughts and feelings about what was shared? How did this podcast change your thinking or clarify any existing ideas you may have had? Reflection: Most students did not seem to listen to the podcast due to lack of time. We had a short discussion about engaging in professional readings/podcasts to help us open our teaching practice to new ideas. Students did enjoy trying out the various assessments and commented that their current assessments did not assess the same skills. Module 4: Reminder to bring supplies to class to create a reading rope out of pipe cleaners and small post-it notes, students will work with their partner to do a deeper dive into two of the "big 5" areas and prepare an in-class presentation Reflection: One group chose to work on each research area alone and each reported back about one topic. They seem to have different ways in which they learn so letting them split up was a better option. Comprehension was not covered by either group so I shared about it. The creation of the reading rope helped students see how the areas come together to help grow a solid reader and writer.
Modules 5 and 6	Module 5: students will work with an online program to spend time in class developing a mockup of a literacy rich classroom. We will look at several pictures and videos to determine if they are literacy rich environments along with pictures from my classroom to find where literacy can be added in. Reflection: Students very much enjoyed the opportunity to look at pictures and videos from other classrooms so that they could critique how much literacy was happening in each of them. They especially enjoyed seeing pictures of my classroom and had lots of great questions about how I include literacy and what their thoughts were on including even more literacy. They did not enjoy watching the videos of Dr. Archer as much as I thought they would, however when I followed up

Modules	Instructor notes
	with some specific questions they were able to give detailed responses with evidence from the video. Module 6: bring a read aloud to class so that I can model how to include SoR elements, remember to discuss learning hierarchy and how this is important when introducing new ideas to children too. Reflection: We spent about 45 minutes in class letting students find culturally rich dramatic play areas and students were able to report all of those on a padlet that they could access in the future. They also enjoyed learning how to include oral language activities in their dramatic play areas, and how students can develop their oral language skills while they are playing. We talked about how this needs to be modeled by students and adults.
Modules 7 and 8	Module 7: practice saying each of the 44 phonemes and discuss what makes learning English more difficult than other languages, show video clips of my students practicing phoneme work. Reflection: Students liked practicing letter phoneme sounds and two commented that as ENL learners themselves it was helpful to practice them so they were saying them correctly for their students. After I showed the videos of my students practicing phonemes, we had a wonderful discussion about nuances in dialect that cause us to pronounce sounds differently. We looked at the phonemic awareness standards for K-2 and tied them back to what my students were doing in each video. Module 8: remind students to bring a book so they can practice concepts of print tasks with each other, also bring elkonin boxes and manipulatives for students to move as they segment sounds. Reflection: Tonight, students really enjoyed learning how to use the elkonin boxes and being able to practice with each other using them. They also enjoyed trying out the concepts of print assessment on each other and had good questions how to scale that up for students who are in second grade who may not have concepts of print or may have concepts of print but need to show a deeper understanding because the texts are more complex in second grade we also had a great discussion about how visually letters can make learning them difficult for some students especially b, d, p, q and h, n, i, l..
Modules 9 and 10	Module 9: Show small group instruction video, and bring materials to model a micro teaching lesson, Be sure to bring cubes, letter cards and elkonin boxes. Reflection: It is very interesting to note how much engagement in class goes up when I am directly modeling something for the students that I use in my own classroom. Tonight's micro-teaching

Modules	Instructor notes
	lesson might have been one of their favorites based on their excitement level and how much they enjoyed manipulating the cubes and interacting with the letter cards. After I modeled my lesson, students had to create and model their own 5 to 7 minute lesson. I gave them 45 minutes to do this in class and it was amazing to see how many of them developed an hour-long lesson instead, so we talked about how these lessons need to be very short and quick moving so that they hold student interest much like it was when I modeled my lesson for them. Module 10: watch mighty moves videos and discuss after each one what the teacher was doing and what the students were doing. Model using the blending board and bring examples of decodable books. Reflection: It was interesting to note what the students picked up on as we watched each mighty moves video. It was evident that they have learned more about the science of reading strategies based on the responses that they gave to watching each mighty moves video. They were able to pick up on specific things that the teacher was doing and specific skills that the students were learning in each activity. Also, when we used the blending board online, many of the students had not used blending as a skill with their students, mostly based on the age of the children that are in their daycare centers with them each day, but they enjoyed seeing how blending boards were used with the children they are working with in this course. It was also interesting to help them understand what a decodable text was. Many assumed that they were the leveled books or step up books that you can buy at many stores and they found out quickly that those books were not decodable. so we spent a lot of time looking at sources online or downloadable decodable books and made sure that they were able to identify a decodable book versus a not decodable book.
Modules 11 and 12	Students worked online, independently this week as we did not have class together.
Modules 13 and 14	Module 13/14: Bring The Napping House big book to class along with index cards and my own micro teaching mini-lesson. Reflection: I was observed tonight by my supervisor and she watched me teach a big book lesson that demonstrated before, during, and after reading comprehension activities. We warmed up by practicing letter sounds then moved into developing comprehension. After I finished reading the big book to students as a teacher, we debriefed the lesson and talked about why it was important to activate prior knowledge for students as well as building background knowledge based on some of the words in this children's book. It was a great discussion to tie into ways to introduce different tiers of vocabulary words and reminded me that I need to look in my own teachers manual for these important vocabulary words when I am teaching my kindergarteners as well. The second part of the evening was spent having students develop their own micro-teaching lesson where they had to do a

Modules	Instructor notes
	letter / sound warm up and then create a comprehension lesson with before, during, and after comprehension components.
Modules 15 and 16	Module 15/16: bring final pictures/videos of classroom and ask students to talk about which skills are being practiced in each, based on the “big 5” areas of SoR, complete surveys, students will share their lessons. Reflection: During tonight's class my students wanted to make sure that they understood each of the signs of reading components, so I took pictures and videos of my students practicing different skills and played them for my students to see if they could identify which of the big five areas that my students were engaged in. They did very well identifying each of these and were able to give characteristics to state how they knew students were practicing vocabulary or comprehension or phonemic awareness or phonics or fluency. Finally, tonight students shared their lessons that they had been working on for the entire 8 weeks, and it was really great to see how they took all of the feedback that I gave them from each of their lessons and use that to create some very rich science of reading lessons that they can use in their future classrooms.

Discussion

I found that much of the growth that I made during the teaching of this course came from the delivery of the course content. I tried to do as much learning about the science of reading before starting my kindergarten year and before teaching this course so that I could confidently answer student questions once in class. I quickly realized that I had most of the knowledge I needed from the learning I had already done to prepare myself and in the process discovered several resources that I was able to share with my students in class. As previously shared, the course was already designed for me, however, I was able to add extra content to the coursework as needed to fit the needs of my students. By the end of Module 4, my students were participating in the course and asking lots of thoughtful questions, however, they were fully engaged. This was also when the content in the course shifted away from being more introductory to diving in more to the “big 5”, and I was able to show classroom examples of the science of reading in action and make connections to what we are learning in class to how that translates to classroom practice. Students also really enjoyed when I brought items from my classroom and modeled how to use them. In the class session where we worked with Elkonin boxes and preservice teachers had the opportunity to learn how they were used and why they were used, I noticed that their engagement went way up, as I knew it would, and that they began to look at the areas in science of reading differently. Many students when they entered this class had the impression that the science of reading was a curriculum or a framework, not understanding that it is a body of research that tells classroom teachers about best practices to use when teaching children how to read. In showing preservice teachers how the practices play out in a classroom, it changed their thinking and their want to learn more. They wanted to know how what they were learning in class happens in a classroom, so I adjusted my lessons each week to include hands-on practice or watching videos of my students doing the things we learned about in class. Walking in to teach this course, I planned to learn alongside my students about the science of reading and found that I had the knowledge that I needed, however, there were student questions in class and discussion posts that helped me to dig into several areas to find answers to ideas my preservice teachers wanted to know more about.

In reviewing the responses given by the preservice teacher in the pre teaching survey, I could infer that they had some knowledge that the science of reading existed, however, they were not clear on many of the details, which I think is representative of the education population before they are explicitly taught about the science of reading. I did not look at the survey responses given by this student until after the course was over as I did not want to bias myself and specifically teach into the areas related to the survey questions. This student attended the course in person, except for one week where they were ill and an additional week, they joined online. This student sat in the front seat for the entirety of the course and participated frequently in in-class discussions and activities.

When reviewing the students initial responses on the survey, it is evident that they have some awareness of the science of reading strategies, however, those seem to be based on their use of the Zoo Phonics curriculum. According to the Zoo Phonics website, the Preschool program "will help you easily teach the alphabet, phonemic awareness, rhyming, pre-sound blending, and pre-writing skills (Zoo Phonics, 2025). When comparing the included components of the Zoo Phonics program to the responses given by the student, the knowledge they have of some of the science of reading is limited to phonemic awareness and phonics. Comprehension, fluency, and vocabulary development are not included in this program and reflected in the response quality on the survey. The student shared that they would develop students' reading fluency through the use of Zoo Phonics. A similar response was given when asked about the strategies that the student would use to teach vocabulary words, “I use zoo-phonics and I use sight words, along with books and hands-on activities like tracing a letter in paint or salt”. When asked how they teach comprehension, the student responded, “Taste test Tuesday. We use a white board and a food item that starts with the letter of the week. We make predictions and we write our predictions on the whiteboard.”

Responses that were given after the course ended in these areas included growth in the students thinking, “picking readers that are at their level will help generate interest and therefore it is easier to work with these skills”, “ I would use visuals to teach vocabulary”, “prior to reading, create a word bank of the vocabulary that my students will see throughout the unit, as we work with other subjects those new words will also be added to our list”, “by asking questions about prior knowledge on the subject or topic and asking open ended questions for critical thinking”. The student did not reference Zoo Phonics in any post survey responses, instead, responses reflected topics covered in the course and learning from in-class discussions. The quality of the responses increased as well, with many key science of reading terms being used along with a shift in thinking about how students learn to read. It is interesting to note that where this student grew the most was their learning about comprehension, vocabulary, and fluency. I think that this growth can be attributed directly to the course content, as this student primarily works with 3 and 4 year old children and relied heavily on Zoo Phonics curriculum to guide their literacy teaching. We had continuous in-class discussions about the developmental appropriateness of curricular materials, activities, and each of the science of reading components to ensure that students understood how they could best work with children at different ages and ensure that they were not asking students to learn concepts that they are not developmentally ready for.

This student had more knowledge of the concepts that are explicitly stated as being included in the Zoo Phonics program, phonemic awareness and phonics. When responding to the question, How would you explain the concept of phonemic awareness and how would you assess a student's level in this area?, the student shared, “I teach phonemic awareness through Zoo Phonics. I assess this individually in the fall and spring during assessments. I test to see if they know their letter sounds and whether or not they can recognize their upper and lower case letters.” The student did share that they would start by teaching upper case letters to students, then lower case letters, and then sight words. There was no mention in this response about letter sounds.

There was a shift in the students' thinking in the areas of phonemic awareness and phonics as well. They better understood that phonemic awareness is “the recognition of sounds and phonemes”. After using several different phonemic awareness assessments in class, the student decided that the DIBELS assessment gave them the most detailed information for working with their students, even more information than the Zoo Phonics assessment they had been using. They also shared that phonemic awareness, “is the recognition of sounds, students will learn how to isolate, blend, segment and finally manipulate sounds.” In the pre course survey, the student connected phonics to letter sounds with no mention of printed words or text, however in the post course survey, they shared that phonics is “a method of teaching people to read by sounds with letters or groups of letters in an alphabetic writing system.”, showing that they had made the connection to written text and symbols.

I was pleased with the growth that we both made during this course. I ended the course feeling confident that I taught the course content as fully as I was able and that my students made growth in their understanding of the science of reading. My growth was less in the specific content and focused more on the delivery of the content, including making sure I included as much hands-on practice as I was able, using pictures and videos of my kindergarten students to show how strategies looked in practice, and making sure we debriefed often during class to ensure there were no misconceptions. I continually changed or adapted my teaching methods during this course with feedback from my students to ensure that they were seeing and understanding how the science of reading looks in practice with children. After receiving explicit instruction about the science of reading and how that translates into a classroom, my student(s), as evidenced by the growth in their survey responses, also increased their knowledge and understanding of the science of reading. In the post course survey, the student noted, “I think all of the lesson plans (that were written in class by students) incorporate the science of reading. I think our final project was where we put everything we learned into practice in this course. I know more through this course and it makes sense.”

Recommendations

The first recommendation I would make is to increase the number of students participating in the survey. I had four students enrolled in this course and as it was a necessary course to roll out, the college let me teach the course with a low number of students. It was my hope that more students would participate and I think more participation would have shown that the explicit teaching of science of reading content can increase student understanding, even when those students come to the course with different background knowledge.

Second, it is always important to be prepared for students who are skeptical about a particular way of teaching. As the science of reading quickly became a politically charged topic, there are classroom teachers who naturally fall on either side of the issue and this was the case in this course. The student who responded to the survey entered the course very confident in the background knowledge they already had and expressed several times during our first class meeting that that was the way that they were going to continue to teach their students. Over time, as we progressed through different activities in class, readings, and discussions, that stance began to change and soften, and their responses on the survey reflect that change.

For any instructors who may be teaching a course with similar content, I would recommend that you keep track of the professional texts, articles, and other readings that you read before and as you teach your course. I was only able to find some of the professional texts and articles that I read before teaching this course. I wanted to include information from some of the texts that I read, but could not find or remember which texts I gleaned information from. I also think it is important to show your preservice teachers that it is important to keep reading professional texts and articles, even when you are teaching them the course content. New ideas are published frequently, replacing ideas we are hanging on to that are ineffective and preservice teachers need instructors to model that for them.

Finally, one of the wonderful highlights that was woven into this course for me, was the inclusion of hands-on materials that the students were required to purchase and bring to class. The most used item was a cookie sheet of magnetic letters. We used this tray each week to practice skills on the spot and to replicate what my kindergarten students were demonstrating in pictures and videos. Having those tools with us for each class meeting helped me as an instructor to address questions as they came up in class and I was able to have my students practice the skill. I would recommend that a cookie sheet, magnetic letters, and a few mini-erasers or other manipulatives, be required for students to purchase and bring to every class meeting. Most curricular programs have a similar requirement for children to use during lessons, so it is important that preservice teachers are able to practice using the materials their students will use.

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Chapter 6 - Once is not Enough: Building Intentional Integration for Lesson Planning in Preservice Teachers

Selina L. Bartels , Benjamin Boche

Chapter Highlights

- This chapter discusses how a preservice elementary education program integrates methods coursework in a series of modeled lessons in an effort to help preservice teachers to write integrated unit/lesson plans.
- The findings from this study indicate that modeling, engaging, and reflecting on the integrated lessons is not enough for preservice teachers to write an integrated lesson plan.
- Future work will investigate highlighting integrated unit/lesson planning with leading with the science question as well as understanding the differences between engineering and science teaching.

Introduction

Scientific literacy is the overall goal of any school-based science teaching worldwide (Bybee, 2015). Once students leave our classrooms, they are faced with daily challenges and decisions that are rooted in being scientifically literate. These decisions can be big or small; for example, when they go to the grocery store, they may decide if they should purchase organic or non-organic produce. Or, when faced with a medical decision, they may need to decide which treatment route to select or when to get a second opinion. Young children, too, are faced with science decisions regularly, such as deciding if they need to wear rain boots today based on a weather report or how fast to pedal their bike down a steep hill.

As teacher educators, it is our role to prepare teachers to be able to teach science in the elementary classroom to develop scientifically-literate students. Most often science is not taught in the elementary classroom or is relegated to the last 30 minutes at the end of a busy school day (Blank, 2013). With the time constraints of the elementary classroom and a push towards a literacy and mathematics focused classroom, the ability to integrate science into literacy is a potential method of teaching towards literacy in both reading and science for our younger learners.

The focus of this chapter is to explain how we integrate literacy and science methods coursework in our preserve teaching program to help prepare our students to be able to teach integrated lessons in their future classrooms. Learning to deliver integrated lessons maximizes teaching time and creates more authentic learning experiences for elementary students. This chapter seeks to examine a practice of integrating the teaching of vocabulary and comprehension within the constructs of an inquiry focused science lesson that teaches towards building scientific literacy. The action research question is: How do preservice teachers integrate vocabulary and comprehension into an inquiry-based science lesson plan? This chapter seeks to examine how preservice teachers write a science lesson plan that integrates science and literacy in a supported environment.

Literature Review

This chapter is looking to bring together larger literature backgrounds: the teaching of foundational literacy, the teaching of elementary science, inquiry-based science teaching, and integrated teaching. The following sections will describe the larger bodies of research in each of these areas.

Literacy Teaching

The Science of Reading refers to the vast, interdisciplinary body of scientifically-based research about reading and issues related to reading and writing focusing on a preponderance of evidence to support student learning outcomes (Reading League, 2022). This includes a focus in areas such as phonemic awareness, phonics, fluency, and for this chapter's focus, vocabulary and comprehension.

There are four components of an effective vocabulary program: 1) wide and extensive independent reading, 2) instruction in specific words, 3) instruction in independent word-learning strategies, and 4) word conscious activities. (Graves, 2000). In particular, specific word instruction and word-learning strategies are part of intentional vocabulary teaching and often the focus of preservice teacher education. Word-learning strategies include dictionary use, morphemic analysis, and contextual analysis (Honig et al., 2018). Additionally, Beck & McKeown (1985) recommend selecting words based on its level of utility, or tier, including tier-one (basic words), tier-two (best words for explicit instruction) and tier-three (specialized content words). Primary grade instruction for vocabulary includes using student-friendly definitions or explanations, providing strong instructional contexts that provide strong clues to a word's meanings, and providing short, playful and active engaging opportunities for students to interact with words and accurately process their meanings (Beck et al., 2013).

Reading comprehension is based around three interrelated elements: the text, the reader, and the activity and related tasks (Snow, 2002). Reader competencies include fluency, vocabulary and word knowledge, comprehension strategies, and motivation. Texts are usually broken down into literary or informational texts and focus on various dimensions such as its purpose, structure, language, and background knowledge demands. Guthrie et al. (2004) describe reading activity and related taste engagement as interactions that are motivated and strategic. The National Reading Panel (2000) identified several key comprehension strategies, or conscious plans that readers apply, for making sense of a text. Key strategies include monitoring comprehension, predicting, asking and answering questions, summarizing, and constructing mental images. Finally, it is recommended that texts are purposefully selected to support reading comprehension, specifically to help support and develop background knowledge in content areas (Shanahan et al., 2010).

Scientific literacy

Scientific literacy understandings fall under three large areas of understanding: science content knowledge as well as understandings about nature of scientific knowledge (NOS) and how scientists engage in scientific inquiry (SI). These understandings of what science is as well as how scientific knowledge is formed (Rogers & Bybee, 2014). Frequently when thinking about the teaching of science, teachers imagine the content they will be delivering. For example, in kindergarten they think about teaching life cycles through hatching chicken eggs and butterflies.

The current US science standards (Next Generation Science Standards; NGSS National Research Council, 2013) are over a decade old and the focus has gone beyond teaching purely content while the practice of teaching understandings beyond content has not. The NGSS interweaves understandings about science as well as how scientists do their work through science content. These standards begin with the youngest grade of kindergarten and go through high school. Although these standards should have been in practice for the past decade when science is taught, in elementary schools the focus is largely on the content such as life science, physical science, and earth/space science (Hanuscin & Zangori, 2016). This has left science to be about memorizing content rather than understanding processes, analysis and informed decision making.

Along with teaching science content, teachers of our youngest learners need to teach students what science is and how it is different from other content areas including who scientists are and how they do their work. The aspects of science they should be interweaving within in the science content are that science is tentative, subjective, creative, based on observations and inferences, and empirically based. Additionally, students need to know that science investigations begin with a question, scientists collect empirical data to answer their questions, scientists use data and prior knowledge to answer questions, and there is no single scientific method (Lederman & Bartels, 2018). It is critical that during a science methods course preservice teachers are learning how to deliver research-based lessons that teach towards scientific literacy, not just science content knowledge.

Delivering Inquiry-based Science Instruction

Inquiry-based pedagogical instruction (Wang, 2019) is an intentional student centered method of delivering science lessons to introduce and teach aspects of scientific literacy. Instead of the typical cycle of reading about a subject then answering questions about the article they read, students will experience an investigation that is open-ended to intentionally teach not just science content but at least one another aspect of scientific literacy alongside the content. This approach to science teaching models the approach that scientists use to help students to own and "discover" the knowledge themselves rather than being told the knowledge either through lecture or reading science facts. Scientific inquiry investigations have three essential parts: a question to describe the problem, a procedure to answer the question, and possible solutions for the problem/question. These three parts of an inquiry investigation can be ordered in terms of a continuum of inquiry for science classroom instruction (Lederman, Bartels & Akerson, 2025). The levels depict the continuum of doing an inquiry investigation from being entirely teacher centered towards being entirely student centered. Lessons that are at a zero are when the students are given the problem they are solving, and the procedure, and already know the outcome of the investigation. Level one is where the teacher provides the problem and tells the students how to go about investigating the question, but the students do not know the answer to the question. When the students are given the question and then allowed to create their own procedures, they are at a level two investigation. Finally, the highest level of scientific inquiry you can engage your students in is a level three where they determine their own question, procedures to investigate and the solution is unknown to them. Delivering a science investigation at a level one through three is considered an effective way to deliver science lessons.

Integrated Teaching

Integrated teaching is the delivery of subject specific content across at least two content areas where there is equal respect in the delivery and assessment of all of the content areas (Boche, Bartels & Wassilak, 2021). This is compared to a thematic or interdisciplinary approach where connections are present among content areas, but equal weight is not given to both. The goal is to build knowledge in both content areas in order to better help students remember information from texts and better support them to engage in inferring and higher-level comprehension processes (Pearson et al., 1979). In particular, reading instruction can be more effective when it is situated in knowledge-building goals than in a generic context (e.g., Guthrie et al., 2004; Halvorsen et al., 2012). While integrated teaching can occur at any grade level, it is most often seen in the early childhood setting (PK3-2) where knowledge building is of particular importance to set the foundation for later learning. This study will use literacy and science teaching strategies through an inquiry teaching approach to build functioning literacy in both reading and science content areas in K-2 grade levels.

Methodology

The focus of this chapter is to describe the action research process used to teach integrated teaching of science and literacy rooted in the science of reading literature in a preservice elementary teaching program.

Participants

The study for this chapter took place in the 2025 spring semester. There were 27 preservice elementary education students in this study. This was a sample of convenience as all the students enrolled in the undergraduate program in the third year were part of this study. There were four students who identified as male and 23 who identified as female. Twenty six out of 27 students are traditional undergraduates with one student who was older than the norm and returned to university to complete their studies. For the purposes of this study, 14 of the 27 students were chosen who had written lesson plans at the K-2 grade levels.

This study occurred at a traditional in person based small liberal arts university. The preservice elementary education program is a cohort model where students all take the same courses together as a group. The bulk of the methods coursework is taken during the third year with the foundational coursework (educational psychology, classroom management, education technology and history of education) are taken in the first two years of coursework. Along with the foundational coursework preservice students also take content coursework (science, social studies and literacy) in their first two years establishing content knowledge of subject areas. The third year program consists of two semesters. In the fall the students take four courses: curriculum and assessment, foundations of literacy, social studies methods and fine arts integration. Along with these four courses, they participate in a three week full day practicum experience in a local elementary school. During this time university courses do not meet. Each student is paired with a teacher and they teach at least two full lessons during this experience. In the semester that this study took place, students were enrolled in four methods courses: science, mathematics, literacy, and physical education integration. This semester also includes a three week practicum experience, and this study took place before the second practicum experience.

Treatment

This study took place as a joint effort between two elementary methods courses (science and literacy). In each course, the professor modeled research based strategies for delivering an integrated lesson within their content area. The professors reflected after the modeling and tasked the students with writing a three day unit plan with the science standard as their focus. Each student was assigned a science standard from the NGSS and selected a text related to the content of the standard. Day one of the unit plan was teaching vocabulary from the text needed for the investigation. Day two was a comprehension lesson of a text concerning the investigation content. Day three was engaging in an investigation of the science concept using an inquiry style of investigation teaching towards at least one aspect of scientific literacy. Students were tasked with writing three sequential lesson plans using the university lesson plan template. They then were to deliver these lessons in a microteaching experience. Microteaching took place in classroom lab spaces that had four students per group. All lessons were video recorded.

Data Collection and Analysis

There were 14 preservice students in the sample who each wrote three sequential lesson plans. A total of 42 lesson plans were collected for the research question of looking to see how preservice teachers incorporate SOR literacy strategies into scientific inquiry lessons teaching towards scientific literacy in early childhood grades. Of the 42 collected lesson plans, the 14 scientific inquiry-focused lessons were examined. Then, each lesson plan was coded to identify the following aspects: level of inquiry teaching, teaching towards scientific literacy and incorporation of vocabulary/comprehension teaching strategies from the first two lessons. The authors coded the lessons together reaching at least an 80% agreement on all codes.

The level of inquiry teaching was determined by the using the Herron's scale described above in the literature section. Each of the early childhood lesson plans were scored a zero through three. They were assigned a zero if the students were assigned the science question and already knew the outcome. A one was assigned if they were given the question and the methodology but the conclusions were unknown. A level two was assigned if they were given the question but the students could determine the methodology. A three was assigned if students were developing their own scientific questions within the theme.

Each early childhood science lesson plan was then coded to identify the aspect of scientific literacy (SL) the preservice teacher was actively teaching toward within the lesson plan. Actively teaching means that not only did the preservice teacher identify an aspect of SL but also engaged the students in reflecting about that aspect. Merely mentioning an aspect of SL is not active engagement. The aspects that were coded for this study were that science is: tentative, subjective, creative, based on observations and inferences, and empirically based. Additionally, science investigations were coded based on the following: begin with a question, scientists collect empirical data to answer their questions, use data and prior knowledge to answer questions and there is no single scientific method. These aspects have been identified in previous research on the aspects of SL that are achievable for young children (Lederman & Bartels, 2018).

Finally lessons were then coded for incorporation of science-of-reading based vocabulary and comprehension strategies modeled in methods class. For vocabulary, this included: asking questions, providing examples/nonexamples, finishing sentence starters, providing student-friendly definitions, examining words in different contexts, picture sorts, examining word parts, using the dictionary, and using context clues. For comprehension, this included: the strategies mentioned earlier, specific fiction or non-fiction text strategies (i.e. predicting, story structure, text structure such as cause-effect), and the use of graphic organizers.

Findings

Of the 27 preservice students in the courses, 14 of the students were assigned early childhood science standards (K-2). These early childhood science lesson plans were coded for their level of inquiry planned to engage the children in, their intentional teaching towards SL, and their integration of vocabulary and comprehension within the science lesson.

Engaging Students in Scientific Inquiry

Of the 14 early childhood science lesson plans analyzed for their level of scientific inquiry teaching based on the Heron's scale, six students did not plan to engage their students in scientific inquiry. Six students planned to engage their students in scientific inquiry at a level one. For example one preservice student's plan was to have students engage in an investigation looking at visual signals versus auditory signals. They gave their students a specific question to investigate and set up stations around the room for them to investigate and record data. Finally they planned for students to make data driven conclusions. Two preservice students planned for level two investigation where they gave the students a problem to solve and the process/method for solving that problem was up to the students. Incidentally both of these level two investigations were also engineering problems versus science problems. No preservice students in this sample planned for a level three investigation.

Planning to Intentionally Teach Towards Scientific Literacy

Six out of the 14 preservice students intentionally planned to teach towards an aspect of scientific literacy in their lesson plans. Five out of the six focused their intentional teaching around what is a scientist. For example a preservice closed their lesson with, "What did we do today that made us scientists?" One preservice student tried to incorporate teaching about being a scientist by asking the students, "What made you feel like a scientist?" This could promote misconceptions about "school science" being different from science done by professionals.

Two preservice students planned to intentionally teach two other aspects besides who are scientists in their inquiry lessons. One preservice student intentionally planned to discuss that scientists collect data and use it to inform their conclusions by writing, "Let's look at the observations that you'll be making over your investigation. You'll draw what you see with both the small and large tuning fork. Then you'll write your observations and conclusions." Finally one other preservice student planned to say, "Today as scientists we will be conducting an investigation. We will be answering the question." These two students planned to make statements about aspects of SL but did not engage their students in making these connections.

Planning to Intentionally Teach SOR

As mentioned previously, the preservice teachers engaged in a three-day unit sequence where the first two days were literacy-focused around a text covering the science content area assigned in the standard, and the third day was the science investigation. Preservice teachers selected a text ahead of time that covered the science content and selected two or three tier-two vocabulary words from the text to teach in the first lesson. They then read this text and engaged in comprehension strategy instruction in the second lesson. Part of the goal of this three-day lesson was to examine whether or not preservice teachers would carry-over any of their first two lessons into the science investigation lesson. Out of the 14 science investigation lesson plans, 8 lesson plans included deliberate literacy integration with varied depth of literacy integration.

Four of these eight lessons specifically integrated vocabulary teaching that included strategies modeled in class. One lesson started by reviewing the vocabulary words 'energy' and 'matter' by using an example: "I'm using energy right now because I'm talking. If we were to pick up our pencil and let it fall, the pencil is using energy too. (*pick up pencil and let it fall)*." This was immediately followed by the preservice teacher asking students to think of using energy in real life and then sharing with a partner by completing the sentence "I used energy when_____." This same process was repeated for the word 'matter.' Finally, the preservice teacher held up pictures of sound waves and energy waves and asked the students to compare and contrast what they saw to introduce the term 'sound wave.'

Another lesson taught the words 'orbit,' 'revolution,' and 'rotation' by first providing definitions of the words and then using a globe, a flashlight and tilting both the globe and the the light from the flashlight to demonstrate how the orbit of the earth impacts the amount of light from the sun to influence seasons. After a quick demonstration, the preservice teacher showed a picture of the earth's orbit followed by the students moving a balloon (as the earth) around the sun and asking questions like "How does the change of the tilt of the earth in the winter compare to the fall/spring?" The students then discussed these terms using sentence starters such as "In winter, the Earth is tilted __________, and we get __________ sunlight. In spring/fall, the Earth is tilted __________, and we get __________ sunlight."

The other four integrated lessons involved varied integration of reading comprehension into the lesson. One preservice teacher started their lesson by doing a picture walk of the book from the previous lesson and stopping at specific pages that focused on seeds and their specific needs on how to grow before launching their science investigation. After examining real plants during the investigation, they ended the lesson by asking the questions “Is there anything you notice about the plant here and the plant that is in the story?” and “The flower in the book and the flower right here might not look the same, but do you think they share the same parts? What are the parts that they share?” The lesson plan also noted to refer to pictures in the book to inspire answers.

Another student based their science investigation on clouds and weather around a text. The preservice teacher started by giving a brief summary of the book (kids at a soccer game notice a change in the clouds and wonder whether or not the weather will impact their soccer game) and then started reading the text and stopping at planned points to ask questions (i.e. “What kind of weather has been mentioned?” “How do the characters respond to the weather?”). After learning about different types of clouds and their functions, the lesson ends by connecting back to the text by “having the students hypothesize what would be the final weather pattern of the story.”

Integrating Science and Literacy Teaching

Three of the preservice teachers in this study were able to plan an integrated lesson that engaged students in scientific inquiry, taught an aspect of SL and integrated literacy. All three preservice teachers selected to teach students at a level one of scientific inquiry, providing the students with the question and the methodology for the science investigation. The preservice teachers planned for three different aspects of SL to integrate; investigations begin with a question, scientists collect data and what is science. Two of the three preservice teachers made connections to the book that they previously read in another lesson. One of the preservice teachers planned to make concept maps with vocabulary words whereas the other two teachers connected to vocabulary.

Discussion

The focus of this study was to examine how specific modeling of research based integrated teaching strategies for literacy and science instruction would result in preservice teachers being able to write lesson plans that also incorporated this teaching focus. A little over half of the sample (eight preservice teachers) wrote lesson plans that engaged students in scientific inquiry. Six wrote level one inquiry lessons and two wrote level two. Another interesting observation was that the level two investigations were engineering problems versus science questions. Potentially the discussion of engineering and the differences between science and engineering teaching should be moved earlier in the semester (versus at the end of the semester). No students wrote lessons that engaged students at a level three inquiry lesson. This brings into question preservice students' ability to write scientific inquiry lesson plans. Should this be a sole target of the first lesson plan in science methods coursework or should teaching scientific literacy along with integration be the initial assignment, perhaps integration teaching should be scaffolded?

If you examine specifically preservice teachers' ability to intentionally teach towards scientific literacy this study found that six teachers were able to incorporate this into their lesson planning. Five out of the six teachers focused generically on the aspect of "what is science/who are scientists". This is easy to incorporate and teach so it is not surprising that preservice teachers choose to incorporate this aspect of SL. The larger question is why did eight preservice teachers leave this out of their lesson plans. A previous research study found that different modeling strategies better taught different aspects of SL (Akerson, et. al., 2014). This may also impact this sample where although several integrated SL lessons were modeled in the university classroom over the seven weeks the preservice teachers could reflect and discuss teaching strategies but were not able to come up with their own.

The integration of literacy into the science investigation lesson plan was more successful with eight out of the 14 lessons including some sort of literacy teaching. This may be due to having the preservice teachers write two literacy lessons (one vocabulary, one comprehension) prior to the third science investigation lesson. Although we told the preservice teachers they must have a science and literacy standard, objective, and assessment in each of their three lessons, we did not tell them how to incorporate literacy teaching into their science investigation. While eight out of 14 lessons is just above the 50% mark, it is exciting to see that with no deliberate scaffolding, a simple majority of the preservice teachers integrated vocabulary and comprehension teaching strategies into their science lessons.

Out of the 14 lesson plans analyzed, only three preservice teachers were able to write integrated literacy and science lesson plans. This was not the result we were looking for or expecting. These results indicate it takes much longer than seven weeks of university instruction to be able to write research based aligned lesson plans. Preservice teachers enter the university classroom with their own K-12 science experiences as well as have witnessed science teaching in the practicum classrooms they have observed. These experiences far outweigh the seven weeks of science methods coursework this was similarly found in Gomez-Zwiep's study which indicated preservice teachers understand what they need to do to deliver a science lesson but are not able to create one (2008). Previous studies show that with specific modeling integrated STEM teaching is possible in a joint methods course (Bartels, Rupe & Lederman, 2019).

Recommendations

This study found that modeling and frontloading integrated literacy and science teaching will result in the success of incorporating more literacy teaching and learning into science lessons, but not necessarily more scientific literacy into literacy lessons. As seen, integrating a three-day lesson sequence where the first two lessons are literacy-based and the third a science investigation yielded a minimal success of fully integrated literacy and science lessons. As there was more success with having literacy teaching present in the science investigation lesson due to the sequence of the lessons, teacher educators may consider integrating scientific literacy components into all the lessons rather than just the science lesson. For example, it might have been useful to start the first lesson in the sequence, the vocabulary lesson, by having students integrate specific scientific literacy components such as "we will be learning some words to help us with our observations during our science investigation in a couple of days," or "As scientists, …." There may not have been time to engage preservice teachers with the different levels of inquiry teaching with science in such a short time frame (7 weeks). A follow up study needs to be conducted to see if by the end of the semester (15 weeks) that this amount of coursework will yield better results.

Creating an integrated preservice elementary methods block is a step in the right direction of modeling what a typical elementary teacher will do in their own classrooms (teach all the core subjects). An additional exploration could be two semester coursework for each content area instead of relegating science, social studies and mathematics to one semester.

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Chapter 7 - Beyond the Hook: Action Research on Elementary Teacher Candidates' Use of Children's Literature in Science Instruction

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Chapter Highlights

- This chapter explores how teacher candidates (TCs) use children's literature to support scientific sensemaking in elementary classrooms.
- It presents findings from an action research study conducted in a science methods course by the course instructor with field-based teaching experiences.
- The study identifies common challenges TCs face when moving beyond using literature as a simple "hook" to supporting deeper scientific explanations.
- The study examines how TCs sometimes overemphasize vocabulary when using children's literature, sometimes prioritizing terminology over conceptual understanding.
- The chapter offers practical recommendations for teacher educators on scaffolding TCs' purposeful integration of literature with NGSS-aligned science instruction.

Introduction

Hands-on activities are popular ways to engage students in elementary science. These experiences are often used to spark curiosity and support engagement (Allaire et al., 2020). However, despite their popularity and efficacy in creating fun entrances to science, hands-on activities are rarely backed by deeper sensemaking (Cook & Dinkins, 2015; Mahzoon-Hagheghi et al., 2018). Many teacher candidates (TCs), especially those with limited science backgrounds, enter science methods courses ready to plan activity-rich lessons but struggle to support students in building meaningful scientific explanations (Plummer et al., 2021; Akerson et al., 2019). This disconnect often leads to surface-level engagement in classrooms where students appear to be learning, but the scientific ideas remain underdeveloped (Nesmith et al., 2017; Kurz, 2018).

One promising yet underutilized approach for teacher candidates (TCs) to bridge the gap between engagement and sensemaking is the integration of children's literature into science instruction. When thoughtfully selected and purposefully positioned, literature can help students contextualize and revisit scientific phenomena in ways that are meaningful and developmentally appropriate (Fang, 2013). However, introducing this strategy to TCs may not be enough; they often need explicit guidance in choosing appropriate texts and using them to promote deeper thinking rather than simply sparking interest (Roy et al., 2025; Stone & Conrad, 2017).

Recognizing these challenges and opportunities, this chapter investigates how TCs used literature during a field-based science teaching experience and what kinds of instructional support might help them integrate texts in ways that promote conceptual depth. Drawing on the methodology of action research this study highlights how different genres of literature that were intentionally positioned by the science methods instructor in her modeling of science teaching were taken up differently by TCs' as they worked on developing their pedagogical practices.

Theoretical Background

Integrating literacy and science is increasingly being recognized as essential in elementary education, especially as instructional time becomes constrained and content integration is considered a practical solution (Mahzoon-Hagheghi et al., 2018; Nesmith et al., 2017). At the same time, scientific literacy itself has long been regarded as a core educational outcome (National Research Council [NRC], 1996), and more recent frameworks highlight the importance of engaging students in reading, writing, and communicating as scientists (Cook & Dinkins, 2015; NGSS Lead States, 2013). The Next Generation Science Standards (NGSS) emphasize three-dimensional learning, in which disciplinary core ideas, science and engineering practices, and crosscutting concepts are integrated to support sensemaking. Among these practices, constructing explanations and engaging in argument from evidence are also relevant to literacy integration (NRC, 2012; Zhang et al., 2023).

Children's literature can powerfully support these goals. No matter the genre, literature can help students bridge the gap between hands-on activities and abstract ideas. Stories can introduce phenomena through real-world or imagined contexts, and informational texts can provide vocabulary to support claims. When literature is used to anchor or extend classroom investigations, students can connect terminology to their experiences to cement conceptual understanding (Cruz & Breda, 2024).

However, despite its potential, TCs often struggle to use literature purposefully. Many lean heavily on vocabulary as an entry point into science, sometimes introducing terms before students have explored the concepts they describe (Nesmith et al., 2017). As Harlen (2006) explains, vocabulary should not be the endpoint of science instruction. Young learners can demonstrate deep understanding through everyday language and representations well before mastering formal terminology. Without support, TCs may default to procedural uses of literature (e.g., reading a book to introduce a word list) rather than selecting texts that they can return to throughout the unit to scaffold explanation, prediction, or reflection.

Recent shifts in literacy education policy add new layers to this challenge. For example, Science of Teaching Reading (STR) reforms in many states across the U.S. have appropriately emphasized foundational reading skills and led to changes in reading requirements for teacher education programs (Holtz & Moody, 2024). However, these changes also carry the risk of narrowing TCs' understanding of literature's multidimensional role in learning, particularly its potential to support student identity, engagement, and scientific sensemaking. As Bishop (1990) described, books can serve as "mirrors, windows, and sliding doors," offering all students opportunities to see themselves in science and to imagine new possibilities. Therefore, efforts to introduce children's literature as a strategy for supporting scientific sensemaking should not be diminished by these shifts but rather integrated alongside them in ways that enrich both literacy and science instruction.

Research continues to show that children's literature, when integrated within inquiry-based instruction, enhances both reading comprehension and science learning (Mahzoon-Hagheghi et al., 2018). However, literature must be positioned not as an add-on, but as a cognitive tool for sensemaking. This requires explicit modeling and scaffolding in teacher preparation programs. Studies show that when TCs are guided in integrated lesson planning, they begin to see literature as more than a hook. They begin to recognize its role in helping students revisit observations, refine explanations, and build understanding over time (Allaire et al., 2020).

Finally, using diverse literature also plays a role in equity and representation in science education. Books can validate students lived experiences, expose them to diverse scientific identities, and offer imaginative entry points into unfamiliar concepts (Bishop, 1990; Plummer et al., 2021). For TCs to leverage this potential, they must be supported not only in selecting texts but in designing discussions and experiences that connect reading to hands-on science in culturally responsive and developmentally appropriate ways.

Situating the Study

As a first-time science methods instructor at a large Midwestern university, the lead author (Alexis) drew on years of experience teaching kindergarten and first grade to plan her instruction. In her first semester, Alexis recognized a recurring challenge: while TCs excelled at designing hands-on, engaging lessons, opportunities for meaningful explanation of scientific concepts were often limited. This realization prompted her to question how TCs could be supported in moving beyond surface-level engagement toward deeper sensemaking.

In her own elementary classroom, Alexis had often turned to children's literature as a bridge between exploration and conceptual understanding. She curated a mix of narrative and informational texts, reading select titles aloud to spark curiosity while using others to provide background knowledge, introduce vocabulary, and extend scientific ideas. These books sometimes provided structure for a teacher-directed unit, and other times they emerged as resources within student-driven inquiries.

Building on this experience, Alexis worked with the Faculty Coordinator for the Course (Author 3, Meredith) to make thoughtful edits to the next semester's course structure. Together, they intentionally integrated children's literature as a potential tool that TCs could use to help students move from "doing" to "explaining" science. The guiding question of this study became: *How will the teacher candidates take up ideas about different purposes for incorporating children's literature as they plan to support children with developing scientific explanations?*

To explore this question, Alexis employed methods aligned with action research (McNiff, 2017) and called on her co-authors (John and Meredith) to assist her with all phases of the cyclical process: planning, acting, observing, and reflecting. The study was carried out with a class of 16 TCs, all of whom engaged in planning, teaching, and refining a series of four field-based lessons; however only 8 gave consent for their work to be used for the purpose of disseminating the results of this study so it those teacher candidates that are the focus from this point forward.

There were two key adjustments made to the lesson planning, teach and revision process during the spring semester this study was conducted. The first adjustment was something Alexis did specifically for her class of early childhood education majors, which was the intentional integration of children's literature as a tool to support scientific explanation. The second adjustment Alexis made, along with all the other instructors teaching the elementary science methods courses, which involved the introduction of a formative assessment reflection tool. Alexis and Author 3 (Meredith) co-designed this tool for use across all sections of the course, and although the formative assessment reflection tool was not explicitly designed to support literacy integration, it emerged as a valuable resource for understanding TCs' instructional decision-making.

Children's literature was modeled and discussed as one possible support for helping students move from "doing" to "explaining" science. For example, the instructor demonstrated how nonfiction texts could anchor scientific ideas during an "Ice Cream" unit and how a picture book could introduce key vocabulary within a 5E force and motion lesson. Throughout the semester, she shared book recommendations with the whole class and with specific teaching groups, illustrating how a variety of genres, including narrative texts, informational texts, and hybrid formats, could spark curiosity in students and foster conceptual understanding about their assigned science topics.

Method

Research Design

Drawing on action research methodology (McNiff, 2017), the instructor (Alexis) serves a dual role as a teacher and researcher. This approach afforded Alexis the opportunity to systematically investigate her teaching practice while simultaneously supporting the professional growth of the TCs.

The process involved iterative cycles of planning, action, observation, and reflection, focusing on how instructional decisions, particularly the integration of children's literature, supported the TCs' development in teaching science. Data collection and analysis allowed the instructor to examine both the impact of course structures and the evolving practices of the TCs. Throughout this process, Alexis observed lessons, provided feedback, and documented patterns in how the TCs approached science content and explanation.

The formative assessment reflection tool was used to capture the TCs' insights after each lesson. This tool asked the TCs to identify their instructional goals, analyze evidence of student understanding through a chosen formative assessment, and reflect on how their instructional decisions impacted students' conceptual development. All teams were encouraged, but not required, to use literature as one way to introduce science content, prompt reflection, or support explanation.

Participants and Data Sources

As previously mentioned, eight TCs (three teaching groups) provided consent to use their data for research purposes. As part of the course, each team planned and co-taught a four-lesson science unit in a local K–3 classroom over several weeks. This field-based experience was designed to give TCs authentic opportunities to apply instructional strategies, including the integration of children's literature, in real classroom settings. The formative assessment reflection tool was designed to support focused, purposeful reflection. It included structured prompts encouraging TCs to analyze their lessons, clarify their goals, and consider how their instructional decisions shaped students' scientific reasoning. It was utilized both as a scaffold for professional growth and as a data source for analysis. Other data sources included lesson plans and instructor field notes, which were examined to identify how the TCs' instructional decisions evolved across the teaching cycle.

Data Analysis

Thematic coding (Braun & Clarke, 2006) was used to analyze the data. All literature references were flagged, including picture books, informational texts, cookbooks, and electronic texts. Codes were developed both deductively (e.g., literature as engagement, vocabulary support, explanation scaffolding) and inductively based on emerging patterns. Data were sorted by each teaching team to create three case summaries and then compared to identify commonalities and differences in how literature was positioned in relation to science goals.

Researcher Role and Trustworthiness

The course instructor served as the practitioner-researcher, enacting and studying the instructional approaches of the TCs in her course section. To strengthen trustworthiness, coding and analysis were peer-debriefed with colleagues familiar with the course and its context (Author 2, John), as well as guidance on the action research process provided by Author 3, Meredith (the faculty course coordinator). These debriefings helped refine codes and ensured interpretations remained grounded in the instructional realities of the classroom.

Results

The results are organized around three teaching groups, each of which approached the use of children's literature differently within their science units. Lesson plans and formative assessment reflections show how each group selected and positioned texts in their instruction. Literature was used in different ways across all three groups.

Group 1 used a single page from a picture book (*I Wonder Why Soap Makes Bubbles: And Other Questions About Science*) to launch their bubble unit, framing bubbles as the anchor phenomenon for exploring states of matter. A discussion with a poster to collect student ideas accompanied the read-aloud, followed by small-group bubble investigations. Although the book briefly mentioned surface tension, the initial discussion primarily focused on descriptive characteristics of bubbles, such as color and shape. One TC noted in the first formative assessment reflection, *"I think when we read the book about bubbles it was a great way to introduce the concept to them and help them wonder about what makes bubbles strong,"* indicating their intent to use the book to help launch their unit. In later lessons, the TCs verbally quizzed students on surface tension during bubble activities, but this concept was not explicitly connected to states of matter. Confusion about surface tension came up in another formative assessment reflection, where a TC wrote, *"A lot of students were confused by this because they thought the bubbles were floating and not staying on the plate... they had a hard time connecting surface tension to what they were exploring."* The final lesson included bubble art as a wrap-up, with little emphasis on consolidating the science ideas explored earlier in the unit.

Group 2 incorporated a nature-based art book (*Nature is an Artist*) and cookbooks to launch a paint-making unit focused on states of matter and material properties. Lesson 1 used the art book as a creative hook to inspire students to use natural materials for making paints. The anchor phenomenon of paint-making aimed to help students interact with and describe various ingredients, which was met to some extent. As one TC noted in a formative assessment reflection, *"We could see from their work that most students understood what ingredients might make what color… unfamiliar ingredients, like logwood, turmeric, or clay, were more likely to make the color different than expected."* At one point, the term *viscosity* was introduced during a whole-group discussion to help describe paint consistency, which may have resonated with some students. However, one TC admitted, *"We struggled to connect science to viscosity with paint, even though it was part of the reason we made the paints."* In a subsequent lesson, cookbooks were introduced as visual references to spark conversations about how to create and follow a recipe. Students were then tasked with creating and testing their own paint recipes by recording ingredients and steps in their notebooks and worksheets. Still, even after this lesson, one TC reflected that writing instructions remained challenging: *"Students seemed to have trouble understanding what instructions look like and what the purpose of them is."* Across the unit, the TCs guided students in revising paint mixtures and assembling a final class "recipe book" of paint colors and names. While the cookbooks and art book helped launch the unit, they were not revisited in later lessons to reinforce scientific ideas or support conceptual connections.

Group 3 used a free, grade-level nonfiction science article available online (in PDF format) to introduce vocabulary in their magnetism unit, reading the text aloud on the projector during Lesson 2 and pairing it with a worksheet that matched terms such as *attract*, *repel*, and *magnetic field* with their definitions. While students engaged in hands-on magnet stations in Lesson 1 and built magnet-powered cars in Lesson 3, the text itself was not revisited to support ongoing exploration or explanation. Instead, it was used primarily to introduce relevant key terms. One TC noted a formative assessment reflection, *"We introduced the words* attract *and* repel *when we read the book and put them on the word wall."* She later added in another reflection, *"We didn't really go back to the book after the first day, but we kept using the words,"* and in the final reflection, she observed, *"They used the terms correctly sometimes, but I don't think they fully understood what made the car move."* Although students could recall key terms, they often struggled to apply them accurately to their investigations, with misconceptions such as the assumption that all metals are magnetic.

Across all three groups, children's literature was used primarily at the beginning of each unit rather than woven throughout the lessons. In each case, literature was positioned as a starting point for engagement or framing rather than as a recurring reference for building or revisiting scientific ideas.

Discussion

It was encouraging to see that all three teaching groups incorporated children's literature into their units, especially in the different ways that were modeled in class. However, once each group selected one way to use literature, they tended to stick with that single approach rather than experimenting with additional strategies or revisiting the text as a tool for sensemaking. Instead, literature was often positioned as an activity to introduce or engage students at the start of a unit, without being returned to as a resource for building deeper conceptual understanding or supporting scientific explanation.

Specifically, Groups 1 and 2 used literature as a visual way to launch their units, and Group 2 even creatively brought in literature outside of science nonfiction. Group 3, on the other hand, relied on literature to do the heavy lifting of introducing key terms. These findings highlight a recurring theme, which is TCs need explicit modeling and support to see literature not just as an isolated activity but as a bridge for ongoing scientific sensemaking.

While Group 1's use of literature successfully engaged students and sparked curiosity, its placement as the sole introduction to the phenomenon limited opportunities for students to generate authentic questions or make firsthand observations before exploring bubbles directly. Literature was treated more as a substitute for observing the phenomenon rather than as a tool to support sensemaking. The group may have been drawing on examples from the course where literature was used to launch units on topics more distant from students' everyday experiences, such as volcanoes or dinosaurs. However, this approach may not have been as necessary for a topic like bubbles, which could be introduced through direct interaction, and in fact, were. Although the group revisited the term *surface tension* throughout the unit, they missed opportunities to connect this idea to broader explanations about the relationship between liquids, gases, and molecular interactions. This suggests that the group viewed the book primarily as an introductory activity, rather than as a resource for deepening conceptual understanding across lessons.

Group 2's approach demonstrated how literature can creatively inspire cross-disciplinary learning, yet the texts were positioned more as sources of artistic and procedural ideas than as supports for scientific reasoning. While students engaged enthusiastically with naming and testing their paints, the connection between recipe structure and key science practices like making results clear, repeatable, and easy to follow was not fully explored. The TCs emphasized the creative process but missed chances to explicitly connect observations about ingredient differences (e.g., differences in paint texture or color) to scientific concepts like material properties or states of matter. This suggests that, while literature served as an engaging starting point, the students could have benefited from revisiting the books to discuss the science ideas over time.

By contrast, Group 3's use of literature highlights a tendency to correlate vocabulary acquisition with conceptual mastery. The nonfiction text introduced key terms, but it was not integrated into discussions or hands-on investigations to help students connect the terminology with their experiences. This disconnect was evident in the formative assessments, where students demonstrated partial understanding of magnetic forces but lacked clarity on concepts like pole interactions or why certain materials are non-magnetic.

By treating the text as a single source of definitions rather than a tool for inquiry, the TCs missed opportunities to revisit and unpack vocabulary within the context of the magnetic car challenge or station activities. This finding reinforces the need for modeling how nonfiction texts can be used dynamically through questioning, discussion, and reflection to deepen scientific sensemaking.

Collectively, these examples suggest there is a persistent issue that these TCs used children's literature in very limited ways and not as a means of facilitating discussion, supporting predictions, or revisiting scientific ideas across lessons, all of which are important ways that children's literature can be used in supporting scientific literacy. Instead, texts were often treated as one-time engagement tools or sources of information, as a sort of "present it and forget it" strategy. This pattern points to the need for more explicit modeling and discussion within the methods course, including guidance on how to select literature, position it within a 5E or inquiry framework, and extend its use throughout a unit to support ongoing sensemaking.

Conclusion

The findings of this study highlight both the promise and the challenges of integrating children's literature into elementary science instruction. Consistent with research emphasizing the value of connecting language, experience, and ideas in science (Cruz & Breda, 2024; Fang, 2014), the three groups of TCs in this study incorporated literature into their units in different ways. However, the texts were used as single-point engagement tools rather than revisited as opportunities for prediction, discussion, or the construction of scientific explanations. This limited application suggests that, while literature was seen as valuable, its potential as a cognitive tool for sensemaking was underdeveloped. These findings echo concerns raised in the literature about the need for explicit modeling and reflective integration across lessons (Akerson et al., 2019; Holtz & Moody, 2024; Lupo et al., 2020).

As studies of teacher preparation have shown, the purposeful integration of literacy and science requires explicit modeling, scaffolding, and reflection (Allaire et al., 2020). The findings here align with this literature, illustrating that TCs often replicate modeled strategies but may struggle to adapt or extend them without structured opportunities to reflect and experiment. This highlights for Alexis, and hopefully other teacher educators as well, the need for science teacher educators to not only demonstrate multiple ways to incorporate texts but also to guide TCs in critically analyzing how literature can scaffold sensemaking across the full inquiry cycle.

Children's literature holds significant promise for connecting students' observations to abstract scientific ideas and for supporting key practices such as explanation and argumentation (NRC, 2012; Zhang et al., 2023). However, this study suggests that for TCs, the ability to use literature effectively is not automatic. It must be intentionally taught, modeled, and reinforced through iterative practice. As instructional time in elementary classrooms remains constrained and content integration is increasingly necessary (Mahzoon-Hagheghi et al., 2018; Nesmith et al., 2017), preparing TCs to view literature as a flexible tool that's revisited, rather than a one-off engagement activity, may be critical for fostering both literacy and science learning.

Finally, the findings from this study also emphasize the importance of providing TCs with structured tools that support thoughtful planning, implementation, and reflection, not only in their use of children's literature but in their overall science teaching. The planning tool and reflection guide used in this study revealed that many TCs struggled to differentiate student engagement and content mastery. Their reflections often suggested that while students were engaged in the activities, the core scientific ideas were not fully developed or revisited. This weekly tool also highlighted a lack of clarity in TCs' learning goals and instructional intentions. By requiring TCs to articulate their lesson objectives, instructional moves, and anticipated student thinking through the completion of the planning and reflection guide, the TCs planning process became visible and open to analysis, both for themselves and for their instructor (Alexis).

Recommendations

Moving forward, this study shows that intentionally designed planning tools can help TCs align their lessons and units with broader instructional goals, prompting them to consider how activities, whether literature-based or hands-on, contribute to conceptual understanding. Teacher education instructors should model strategic approaches to planning, demonstrating how to launch, extend, and revisit ideas across multiple lessons to create coherent learning experiences. For example, modeling how a hands-on activity, text, or discussion can be returned to later lessons can help TCs recognize the value of iterative learning cycles rather than isolated activities. Reflection tools should also be scaffolded to go beyond surface-level observations, encouraging TCs to analyze how their instructional choices support student thinking, conceptual growth, and evidence-based reasoning. When combined with targeted instructor feedback and peer collaboration, these tools can deepen TCs' awareness of how teaching strategies work together to achieve learning outcomes.

In addition, structured peer discussions and feedback sessions can provide valuable opportunities for TCs to share approaches and reflect on alternative strategies. This was not something Alexis had incorporated into her instruction the semester of this study but plans to do moving forward. She believes giving her TCs the opportunity to hear how other groups use literature, such as integrating texts during mid-unit discussions or revisiting books to reinforce concepts, could inspire TCs to use literature more deeply to support conceptual understanding.

By comparing successes, challenges, and student responses, peer collaboration can promote experimentation with multiple methods of integrating literature. Furthermore, teacher educators should introduce structured classroom discussion strategies that explicitly connect student observations, hands-on investigations, and reading experiences to scientific explanations. This can help TCs develop a repertoire of approaches for guiding students from curiosity to conceptual understanding, while reinforcing the repeated nature of inquiry and explanation in science learning.

At the core, these recommendations remind us how important it is for TCs to stay grounded in both what they want students to learn and how they plan to get there. Tools for planning and reflection can help make that vision clearer, while also surfacing strengths and pointing to where there’s room to grow.

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SECTION III

Chapter 8 - Stories We Live By: Merging Storytelling and Literacy for Environmental Education

J. Adam Scribner

Chapter Highlights

- Integrating storytelling in the science classroom can play a vital role in helping students engage with literature and can help motivate them to care about environmental issues.
- This action research project aimed to create a framework for science educators to explore environmental education through the lens of storytelling.
- The implemented lesson plan utilized the following lesson sequence: (1) telling my story, (2) reading global stories, (3) having students write their own stories, and (4) reflecting on all the shared stories..

Introduction

Integrating storytelling in the science classroom can play a vital role in helping students engage with literature and can help motivate them to care about environmental issues. This action research project aimed to create a framework for science educators to explore environmental education through the lens of storytelling.

Drawing on my experiences in K12 and university classrooms, I utilized insights from the emerging field of ecolinguistics to co-develop and refine a science lesson that integrates literacy through a "stories-we-live-by" approach (Stibbe, 2015). This includes having students read global environmental stories and writing their own environmental narratives. Through this project, I explored how a structured stories-we-live-by approach can help connect literacy and environmental education.

Literature

Storytelling in Science Education

Communicating scientific information to students can be challenging when the material is presented in ways that exceed their cognitive capacity, often because the content lacks connection to real-world, everyday experiences. This disconnect makes it difficult for students to form the mental frameworks (schemata) needed to understand, comprehend, and retain information (Dahlstrom, 2014). Therefore, the use of storytelling in the science classroom is a promising approach to bridge this gap. Storytelling holds potential as an alternative method for teaching scientific concepts by helping students connect new information to their existing knowledge.

Research shows that the use of narrative formats can be more persuasive and easier to understand than just sharing raw data or statistics with students (Betsch et al., 2011; Hopfer, 2012). Effective storytelling in the science classroom can include multiple forms of engagement including teacher reading, student participation, discussion, and creative tasks like drawing, writing, or acting. Despite these benefits, storytelling remains underutilized in science education, partly due to perceptions that it lacks scientific rigor and the persistence of traditional teaching methods (Olson, 2015).

Ecolinguistics

Ecolinguistics is an interdisciplinary field that examines the relationship between language and the environment. It explores how the ways we talk and write and think shape — and are shaped by — ecological and environmental systems, values, and behaviors. It draws from linguistics, ecology, and environmental humanities to uncover how language influences attitudes toward nature, sustainability, and environmental justice. Core concepts of ecolinguistics include (1) using framing and metaphor: how metaphors like "carbon footprint" or "carbon dioxide works like a heat trapping blanket" influences our thinking, (2) Integrating discourse analysis: how language in media and advertising reflects or resists environmental values, (3) Developing awareness of critical language: reflecting on how language choices influence environmental perceptions. And, most importantly for this study, and (4) Integrating *stories-we-live-by*: examining narratives that shape our environmental worldview (Stibbe, 2015).

Primary and secondary students are developing critical thinking skills and beginning to engage with more complex social and ethical issues, making primary and secondary education a great stage to introduce ecolinguistics ideas in accessible, engaging ways. This may include having students read about stories with ecological values and then writing and rewriting their own similar stories. These lessons will ultimately have students consider how narratives affect our relationships with the environment with the aim of deepening environmental awareness while supporting cross curricular learning (science, language arts, and social studies).

Method

Action Research Approach

In this research study, my goal was to better understand how a lesson developed to integrate storytelling, ecolinguistics, and environmental education can be optimized and improved for middle level classrooms. To do this, I utilized an action research framework that allowed teachers to participate in a designed lesson and provide feedback via a focus group. By implementing the lesson with teachers who were participating in an environmental education professional development program, they were able to recommend strategies and approaches for modifying the lesson while the lesson was being implemented, as well as through a focus group that took place at the end of the lesson.

Collaborative action research, where educators and researchers work together to tackle real-world teaching problems, proved to be a valuable method for exploring the complexities of teaching environmental education using a stories-we-live-by approach that surfaced socially and culturally relevant contexts. This form of research is defined as a cooperative effort between teachers and researchers that aims to address challenges linked to educational and social change (Greenwood & Levin, 2007). Rather than focusing on building or testing theories, collaborative action research emphasizes developing a deeper understanding of teaching practices within specific settings and using those insights to guide educational improvements (Feldman & Weiss, 2010). It also encourages collaboration among higher education professionals and K–12 educators to build shared meaning and drive action through the research process (Bennett & Brunner, 2020).

Participants and Context

The teachers who participated in this action research project were all participants in a week-long summer science institute for a project titled *Educating for Environmental Change* (EfEC). EfEC began in 2017 as a partnership between scientists at Indiana University (IU) and the university's School of Education. Since its inception, the program has equipped teachers with training, resources, and professional development opportunities—including workshops and classroom-ready materials—to help them integrate environmental education into their teaching, primarily throughout the Midwest. So far, the program has served over 700 educators. Collectively, these teachers have reached an estimated 58,000 students—a figure based on the participating teachers reported average class size and the number of years they've been implementing the program in their classrooms. EfEC's programming stands out from that of national organizations like the U.S. EPA, NASA, and the National Center for Science Education due in part to its strong emphasis on place-based curricular materials co-designed by, and for, K–12 teachers in the region.

Twenty-four science teachers participated in the EfEC summer science institute. Fourteen were middle school teachers, six were high school teachers, and four were elementary school teachers. Five of the participating teachers taught for fewer than 5 years, four taught for 6-10 years, one taught for 11-15 years, and fourteem taught for 16+ years. In a pre-survey administered prior to the institute, the twenty-four participating teachers were asked to indicate their level of knowledge and experience teaching specific topics. When asked about their knowledge and experience "integrating storytelling into environmental education," seven indicated that they were unfamiliar with the topic, eight indicated that they knew a little about the topic, and nine indicated that they know a lot about the topic.

Action Plan

There were four phases to this study's action plan. The first was the *design phase* to develop a lesson plan that integrates storytelling, literacy, and environmental education. Second was the *implementation phase* in which I implemented the lesson with 24 teachers. Third was the *focus group phase* in which I conducted a focus group of the participating teachers to solicit feedback on the lesson. And fourth was the *revise phase* in which I utilized the data from the focus group to improve and optimize the lesson.

Design Phase: Prior to the summer science institute, I met with Dr. James Damico and Dr. Mark Baildon to help design my lesson plan. Dr. Damico is a Professor of Literacy, Culture, and Language Education and Dr. Baildon is a Visiting Clinical Associate Professor of International and Comparative Education. Both are at Indiana University's School of Education, and both are affiliated faculty of the EfEC project. Together, they led an EfEC workshop that I participated in titled *The Power of Stories in Our Classrooms: Cultivating Local and Global Perspectives in Environmental Education*. In this interactive workshop, educators across grade levels and content areas in science, social studies, and English language arts explored diverse storytelling formats, examined different methods for crafting compelling environmental narratives, and participated in classroom activities designed to encourage students to cultivate their own environmental stories. Participants left with practical tools and strategies to integrate storytelling into their teaching. One of the tools that was developed for this workshop was integrated into my lesson plan. The tool is a framework developed by Drs. Damico and Baildon that was created to help scaffold student environmental storytelling. With this tool in mind, during the weeks prior to the EfEC summer science institute, I focused on designing a lesson plan that would use the tool to help teachers integrate storytelling, literacy, and environmental education in their classrooms.

Implementation Phase: The lesson plan that I implemented had the following lesson sequence. (1) Telling my story: a story that includes a critical moment in my life that caused me to care about the environment. (2) Reading global stories: reading others' stories from around the world with an emphasis on the reasons that they started to care for the environment. (3) Having the students (or in the case of the professional development workshop, the participating teachers), write their own "critical moment" stories. And (4) reflecting on all the shared stories and looking for common themes. Although I utilized a PowerPoint to guide my lesson, the lesson could have been implemented without it (for example, for the "my story" part of the lesson, I simply had a PowerPoint slide that stated, "my story").

To begin the lesson, I started with "my story;" a critical moment about what caused me to care about the environment and environmental education. I told the following story to the participating teachers:

> *"My story begins when I was attending college. I started college as an oceanography major and then changed to biology, so obviously, I cared a lot about science. I also spent my summers working as a naturalist at a summer camp as I also cared about teaching others about my love for science. Looking back, one reason why I probably gravitated towards science and teaching had a lot to do with my parents; my father was a scientist, and my mother was a teacher. At the time, as an undergraduate student, I couldn't be a traditional K12 classroom teacher, but I could work as a camp counselor at summer camps. How many of you worked at a summer camp? (I waited for the participating teachers' hands to go up. Many of the teachers raised their hands.) Yeah, I kind of feel like when you work at a summer camp, you learn how to be a resourceful educator – and you specifically become resourceful about using the outdoors as a classroom. Obviously, it also teaches you a lot about kids so it's not a surprise that so many of you used to be camp counselors as well. And of course, one of the best parts about the job is that you get to work outdoors, in nature. At the time, I was working at a camp just outside of Philadelphia. It was a camp for inner city kids that was funded by the United Way, so the campers did not have to pay to attend. And there were two camps – one was an overnight camp where campers would stay for weeks at a time and the other was a day camp where the campers got bused each day from center city Philadelphia to the camp. I worked at both the overnight camp and the day camp. I remember being at the overnight camp for long periods of time where the kids (campers) got really acclimated to being in the*

> *outdoors and really loved being outside. We would often go on hikes and "creek crawls". And then I remember showing up on the first day of the day camp and having the kids get off the bus. We said to them 'OK, we are going to break up into groups,' and asked the campers to have a seat in the grass. I remember being struck by how many of the campers didn't want to sit down in the grass. Some said that they didn't like grass. Some said they were afraid of bugs. And I remember thinking at the time just how disconnected so many of these kids – and kids, in general - are from their natural environment. And some of these kids were coming from neighborhoods that many of the campers considered 'tough' neighborhoods. And to think that what might have made them jittery was simply sitting down in grass - or possibly seeing a few bugs. That was very eye-opening for me. It also, I think, identified in some way the privilege that I had growing up. After all, I grew up in a family that would go camping together, go on hikes together. So, that moment – that 'critical moment'- really changed the way that I started to think about my role as an educator. And ever since then, after I became a classroom science teacher, going outdoors became an* important *part of my teaching. Whenever I could, I made it a priority to take my students outside, to get them to make observations of nature and ask questions about their observations. And it is one of the reasons why I continue to prioritize environmental education in the work that I do today."*

After I told my story, I then said, "now let's read more stories – global stories - about other people and maybe we can learn about their 'critical moments' and why they care about the environment, too." I then distributed copies of a story about Boyan Slat for the participating teachers to read. The Boyan Slat story is a true story of a young man who, as a teenager, had a critical moment while visiting the Mediterranean Sea. While swimming in the sea, he noticed more plastic than fish in the water. This inspired Boyan to learn more about plastics in our oceans and ultimately, develop a solution to clean up ocean plastics. Many years later, he is now the founder and CEO of a company called *Ocean Cleanup*. I chose this story for a few important elements: (1) It is a story of a young man – a teenager – who sees a large environmental problem and, as a teenager, comes up with an innovative and plausible solution. (2) The story emphasized a "critical moment," a time in which Boyan Slat determined that cleaning up plastics in our oceans was the problem that he wanted to dedicate his life to solving. (3) The story emphasized grit; the idea that Boyan Slat's ideas didn't always work and that he had to learn from failure. (4) This story could only happen today, using today's technologies. To help solve the problem of plastics in the ocean, Boyan used the internet to raise awareness and crowd-source funding, and he used computer-aided design to create original prototypes. These technologies would not have existed in previous generations. (5) This story takes place around the world, with Boyan Slat discovering the problem in Europe before heading to North America to launch his first Ocean Cleanup prototype, and then deploying cleanup devices in the Pacific Ocean. The story was printed on a two-page handout that all the participating teachers read individually before we talked about it as a group.

To add to the theme of cleaning up plastics in our environment, I then began distributing copies of the children's book titled *One Plastic Bag,* written by Miranda Paul. This is also a true story about a young woman named Isatou Ceesay who grew up Gambia, Africa. She also had a critical moment that encouraged her to act. She noticed that, over time, a pile of plastic bags in her village kept getting bigger and bigger. This led Isatou to come up with a creative solution to recycle the plastic bags into useful items. I chose this story for different, but similar elements: (1) Isatou chose to solve a much more local and place-based problem than Boyan Slat. Her solution primarily impacted her local village, (2) The problem that she chose to solve was similar to Boyan's in that they were both solving problems created by plastics in our environment (a problem that all communities face), and (3) Her solutions to solving the accumulation of plastic bags in her village was simpler than Boyan's – something that any creative young person could have come up with.

After the teachers read this story, we talked about it as a group. I also explained to the teachers that it was my hope that, by reading two stories about young people solving the problem of plastics in our environment, these stories might lead to discussions pertaining to how, as a society, we can clean up plastics, how we might reduce our dependency on plastics, and how we might reduce our consumption of plastics.

After talking about *One Plastic Bag*, I then shared with the teachers other books – books for older students - that could have also worked for the global stories part of this lesson. This included discussions about the novel *Flush* by Carl Hiaasen, and nonfictions books such as *A Long Walk to Water* by Linda Sue Park and *The Boy Who Harnessed* the Wind by William Kamkwamba.

For the final part of the lesson, I asked for the teachers to reflect on their own critical moments. To do this, I used the following graphical tool that I provided to each teacher as a handout. This graphical tool was created by Dr. James Damico and Dr. Mark Baildon at Indiana University's School of Education for a similar storytelling lesson. The tool is a framework for having students (or, in this case teachers) reflect on their own "critical moments" and create their own environmental stories. Using the framework, the teachers then spent time writing their own stories. Afterwards, we shared our stories with each other.

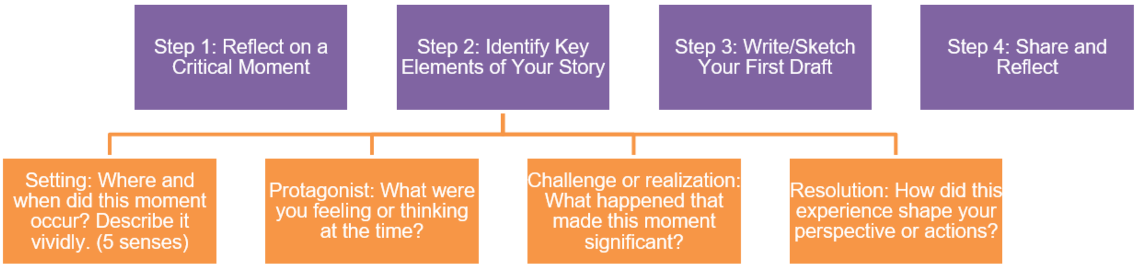

Figure 1. A Framework for Having Students Create their Own "Critical Moments," Environmental Stories (Damico & Baildon, unpublished).

Focus Group Phase: After the lesson concluded, I asked the participating teachers a series of questions. Example focus group questions included: (1) what did you think of the sequence of this lesson (a. my story, b. global stories, and c. drafting your story)? (2) What did you think of the global stories that I chose to share today? (3) What did you think of the "critical moment" writing exercise? And (4) do you have any suggestions for improving the lesson?

Revise Phase: The recorded audio data set was analyzed by identifying categories and coding the data. The results were then collated as findings and results. After the audio analysis data was collated, I used the data to critically improve and optimize the lesson plan.

Data Collection and Analysis

The qualitative data sources that I used included audio recordings of a teacher professional development workshop lesson that I implemented with the participating teachers including recordings of the teachers during the lesson. Having the teachers wear "student hats" and "teacher hats" during the implementation allowed me to lead discussions on emerging teaching and learning themes from the lesson. The emerging themes were then used to steer a follow-up focus group discussion where I also collected audio recordings of the participating teachers. During the focus group, teachers provided reflections and insights pertaining to improving and optimizing the lesson. The implementation of the lesson plan took approximately one hour during the summer science institute and the follow-up focus group took approximately 30 minutes.

Results

Audio recorded data was collected during the lesson's implementation phase and focus group phase of this action research project. The results are collated below.

Implementation

After sharing my story (see the "my story" section in the Action Plan above), I began the second part of the lesson implementation by sharing global stories with the teachers. I started with the story of Boyan Slat. I asked the teachers what they thought, generally, of the Boyan Slat story.

One teacher noted:

> *"Coming from a younger teacher, stories like this are incredibly important. Truly important. Especially stories that show kids making positive changes at young ages. (They show that) it's possible for young people to do it."*

Another teacher stated:

> *"I like that like a third of (Boyan Slat's) life has been dedicated to this. (It tells students that) it's not just like an overnight success story told so many times before. He continues on and continues on and (persists). It emphasizes grit and... that's really important for kids to see. That it doesn't just happen overnight."*

Another teacher said:

> *"Oh, I just love the fact that he's a young person with passion… I also like that there's a part of this reading that talks about the community that he has built. Like, you can support his (Ocean Cleanup) movement. You don't have to be the one that came up*

with the silver bullet idea… It's good to remind our students that although ideas matter a lot, being a part of community also matters a lot, too. (Sometimes that can be) more impactful than just being the person that came up with the initial (idea).”

Another teacher, however, questioned if students would be put-off by the Boyan Slat story:

> *“I think (students) like hearing inspirational stories, but in the back of their mind… they may question his privilege (especially swimming in the Mediterranean) … Stories like this might have students take themselves out of the (ecological problem-solving) equation.”*

After the teachers reflected on the story of Boyan Slat, I then distributed copies of the children’s book *One Plastic Bag*. The teachers read the book, and afterwards, I asked what they generally thought of the story.

One teacher said that he really liked the story:

> *“I grew up on stories like this. My mom is a biology teacher, and so I've been steeped in biology and environmentalism… since I was little. I watched nature documentaries instead of cartoons. So, I've read a lot of books like this… that have some type of environmental lesson. Stories like One Plastic Bag are really important… they helped me to build passion (for environmentalism) and… find creative solutions.”*

Another teacher remarked about the similarities and differences between this story and the Boyan Slat story:

> *“You chose this story to compare with (the Boyan Slat story) because, as we already mentioned, he (Boyan Slat) was a child of privilege, but she was not. If you know anything about Gambia (where One Plast Bag takes place), it's rife with corruption. They have had many coup d'etats and women are not in a very good situation there. There's a lack of education there for women.”*

Another teacher piggy-backed on this observation:

> *“She is a very, very inspiring person and, you know, came from very limited means, in contrast to him. So even if your students recognize that (Boyan Slat) is a person of privilege, well, she's not.”*

Within the lesson, the teachers were picking up on the elements of the stories that caused me to share them. After further discussion, I asked the participating teachers to reflect on the stories. What was the critical moment for Boyan? What changed in him? What was the critical moment for Isatou? What changed in her?

One teacher responded, reinforcing the purpose of global stories component of the lesson:

> *"Boyan saw more plastic in the ocean than fish. For Isatou, it was when the goat started dying and also just the large pile of mostly plastic bags, right? In the United States, we take for granted that we get to put stuff in garbage cans that wind up in landfills that many of us don't see."*

I then pivoted to the next part of the lesson sequence, having the teachers write their own critical moment narratives. I told them that Dr. James Damico and Dr. Mark Baildon believe that "stories operate as a shadow curriculum in our lives" and that I wanted them to bring their stories to light. I handed out the critical moment scaffolding tool (see Figure 1.) and asked them to use it to write their own narratives. I gave them 15 minutes to work independently and write their own stories. I then asked a few of the teachers to share their stories.

One teacher shared:

> *"So, I was probably four or five years old, and I was in my parents' backyard and there was a box turtle that was under the shed, hanging out. And I just remember being amazed by it and watching it with a sense of wonder. I think it (created) a lifelong touch point where whenever I see a box turtle, it's like, oh, there is magic in the world… I'm on a sabbatical this next year and I'm going to be doing research on box turtles up near (local college) and here locally with (a local) land trust."*

Then another teacher said:

> *"Yeah, I don't know if this is the critical moment. I could probably think of more from my childhood, but as a teacher, I have a real moment. I think just a couple of years ago… I spent a year teaching English in Mexico. And it was a really small island community. Growing up in Indiana and then teaching in Indiana, I was pretty far removed from the ocean and from thinking about plastics in the ocean or anything like that - like sea turtles swallowing plastic bags. I remember learning about (sea*

turtles and plastic) as a kid and feeling, oh, my gosh. But living and working in a place where the kids were literally seeing sea turtles every day and seeing trash on the beach got me thinking about our crazy use of plastics. And the influx of tourism and all of these factors that were impacting their very small and beautiful community. It was so impactful for me. This little school where I worked did a lot of work with getting the kids involved. I mean, we went once a week to the beach and picked up trash. This got me thinking about place-based education and starting where you are - and, like starting in your own community. Wherever kids are, there are things they can do."

I remarked about how her story was similar to the stories I shared and how stories can trigger connections. I also remarked about how, unlike the stories that we just heard, stories aren't always positive. According to Stibbe (2015), stories can be both destructive and beneficial for our environment. For example, there are stories about how humans are the "center of existence," separate from nature, or "the primary goal of society is perpetual economic growth". But there are also positive stories that emphasize notions such as "the goal of society is human and planetary well-being". I concluded the lesson by stating that the more that we can get our students to think about their critical moments when they're young, the better the chance that they will gravitate more to the beneficial side than the destructive side.

Focus Group

After the lesson wrapped up, I began the focus group phase of the study. I started by asking the teachers what they thought of the sequence of the lesson (my story, global stories, and then composing their own "critical moment" stories).

A teacher began the focus group by saying:

"If you plan to use this exercise with your own students, your story - and the passion of your story - is incredibly important. It just is… I can remember, as a kid, listening to people like David Attenborough, you know, in documentaries. He had such powerful statements about what he thought was important and what we should be doing to protect our environment… That was very influential for me. So, maybe it will be for our students who may not have the opportunities that I had."

An elementary science teacher then stated:

> *"As an elementary school teacher, I have found it beneficial to get their story first before I share (mine) or global stories because then their story is always about the global issue (that was in the story). For example, if I were to do this same lesson, and then ask them, 'what's your story,' they would somehow tie (their stories) to plastics like in the stories that we read."*

After this comment, we then discussed as a group how students might get idea fixation and create narratives similar to the stories that we share, or stories that we read. One teacher even remarked how similar the teacher's story of plastics and sea turtles was so similar to the stories of Boyan and Isatou.

The same elementary teacher then said:

> *"So, you might start with it, you know, 'how many of you care about nature? Tell me why?'"*

A teacher then mentioned the importance of having diverse voices in the classroom:

> *"I would add that… it's really important to get some representation or else the stories are going to be just one more data point in their mind… They might be thinking are they included in this, or not?"*

A teacher discussed the importance of emphasizing geographical differences:

> *"I always like having (students use) a globe or Google Earth to show them where (the story took place). Where did the story in the picture book take place? So, then they see that our big world isn't so big. So, adding that into the (lesson) sequence, I think because (the lesson) starts closer to home and then it expands."*

Another teacher reflected on that idea:

> *"I use maps a lot, too. And just like (to emphasize different) places and… diversity as much possible in terms of, what you were doing (in the lesson). And including different perspectives like somebody that was really a privileged European white male and then the woman in Gambia… I think just expanding on that more if you can. More time to read more stories – especially stories from more places."*

A teacher then reflected on US individualism and how it could hamper solving global problems:

> *"I think the US is so individualistic that we like to think of problems as mine (my problem to solve) ... So, I think it's really good that (students hear stories)… from different countries about similar issues."*

I then asked the group to reflect on the "critical moment" narrative component of the lesson and how it was scaffolded.

The elementary teacher stated:

> *"Critical' seems so strong of a word for (young learners). And I also think that critical moments can be very small moments in your life – where maybe you don't notice the impact until much later… Yeah, important moments."*

Another teacher added to this thought:

> *"Right, it could be as simple as 'interesting moment', right? Because (looking at the teacher who told the box turtle story), your box turtle moment, when you were a child, you were captivated by it. But now it has changed the course of your life in a way too, right? So, it wasn't 'critical' until it became critical later in your life."*

I then asked the teachers about their thoughts on implementing the writing piece of this lesson; having students write their own critical moment narratives.

One teacher talked about not over-emphasizing grammar:

> *"I think not focusing on the grammar and the spelling, but instead the content, you know, and focusing on the sharing aspect of stories is what I would want to do."*

A high school teacher expanded on this idea:

> *"Well, the last year I taught freshmen, I had them write every day. And sometimes, you know, I would give them credit for volume… I would say to them, do you want to show it to me, or do you want to read it to me? Or do you want me to read it? That way, they were freer to write whatever they wanted. And then there was a lot that they shared with me. And so that's what I was thinking… to let students have the freedom to write without me going through it with a red pen and saying this is spelled wrong*

or you should have capitalized, that kind of thing."

Another teacher held up the critical moment scaffolding tool handout and said:

"These driving questions could be asked by a (student) partner."

And then another stated:

"And somebody else could write. You could write each other's stories!"

With another teacher piggybacking on that thought:

"You could also extend it like if you really wanted to make it a bigger project like having them make their stories into their own picture books and then sharing them with younger students."

A teacher also spoke about the idea of bringing in story tellers into the classroom:

"And then you could bring in other guests that you have, right, like someone that is doing a cleanup at a local lake. You can bring people in to tell their stories."

With that in mind, a teacher reflected on the stories that we read together:

"I just want to say one thing about your story selection. I completely agree with two different areas of the world, two different (economic) classes, but then also scale is really important. So, like one story he's doing a massive thing. He's trying to clean up the entire ocean, you know, he wants to do this by 2040. It's large scale. And then your other story from Gambia is much smaller scale. It's three people that are now working together to do this. So that is also really important, especially for younger people, for kids in elementary school just to see that you can do something massive, but you can also do something really small and still make a difference."

Discussion

The participating teachers offered numerous ways to improve and optimize the proposed stories-we-live-by lesson plan. A few of their suggestions included: (1) beginning the lesson by having a discussion with the students about why they care about the environment. This will reduce idea fixation caused by hearing the teacher's story and/or reading global stories, (2) Deliberately choosing a diverse group of global stories to introduce to the students.

Sharing stories of people from diverse backgrounds and emphasizing how they work to make our world a better place. Also, making sure that there are stories with both simple and complex solutions to environmental problems including global and local solutions, and that each story emphasizes the storytellers' critical moments, and (3) Changing the critical moment framework handout from saying "reflect on a critical moment" to something less "critical". They suggested having students reflect on "important moments" or "aha moments" that influenced them to care more about the environment. And potentially, having students listen to and write each other's stories.

Recommendations

My recommendations for improving this lesson depend primarily on the grade-level of students that I am working with. If, for example, I am working with high school students, I would probably run the activity similarly to how I ran the activity with the participating teachers. If were to work with younger students (middle school or elementary school), however, I would incorporate two of the suggestions noted in the Discussion section. The two suggestions are: (1) beginning the lesson by having a discussion with the students about why they care about the environment (to reduce idea fixation) and (2) changing "critical moment" to "important moment" or "aha moment".

Additionally, there were multiple recommendations regarding choosing the right global stories to have students read as well as recommendations to add extensions to this lesson. A few of the suggested extensions include: (1) bringing in other storytellers to share their stories with the students and giving priority to storytellers who come from similar backgrounds as the students being taught. (2) Having students share their stories orally with partners and then having the partners write their stories. (This will help improve student listening and writing skills.) And lastly, (3) having students write children's books and then sharing them with younger students. This will add student creativity to the lesson by having them add illustrations.

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Chapter 9 - Enhancing Teachers' Self-Efficacy on Fostering Students' Abilities to Communicate Like Medical Professionals through Game-Based Instruction

Gayle A. Buck, Arya Karumanthra, Mahnaz Zolfaghari

Chapter Highlights

- The relationship between education for medical pathways and vocabulary development is examined.
- An emphasis is placed on understanding effective methods to support science teachers in promoting comprehension of medical vocabulary within their classrooms.
- The implementation and analysis of game-based pedagogy as it relates to vocabulary instruction are discussed.
- An empirically guided professional development program is presented to equip teachers with strategies for incorporating game-based approaches to teaching medical vocabulary at the upper elementary and middle school levels.

Introduction

Cancer cases are rising (Katella, 2024), further increasing the demand for oncology services amid workforce shortages. The American Society of Clinical Oncology (2022) reports a shortage of oncologists, with many nearing retirement and only 13.9% in early career stages. Efforts such as internships, scholarships, and early education—including NIH's National Cancer Institute initiatives in K-12 schools—aim to attract more professionals to the field.

Developing proficiency in the language used by medical professionals plays a crucial role in shaping students' understanding of medical careers. The complexity of scientific communication has been recognized, highlighting the need for effective professional communication. Scientific discourse often involves complex language, which can make public engagement difficult. Cultural context and institutional practices influence medical communication, affecting accessibility for those outside the profession. Mastery of professional terminology is a vital part of medical education. Increased student familiarity with medical vocabulary supports their understanding and perspectives on medical careers, suggesting that medical education should emphasize vocabulary development.

Educators teaching medical terminology should have both subject matter knowledge and pedagogical skills, which can be developed through professional development programs. Pipeline programs often require teachers to hold a broad background in biomedical education and research, as these experiences may impact students' interest in related fields. Support for expanding educators' expertise and abilities in career development across educational stages—especially in middle schools—is identified as important (NSTA, 2016).

The research presented in this chapter sought to design a professional development program intended to enhance teachers' ability to facilitate student communication utilizing medical terminology. The primary research question was: In what ways does participation in this professional development initiative influence middle school teachers' efficacy and comprehension when instructing medical terminology? This central inquiry was explored through two subsidiary questions:

- In what ways does the professional development program influence teachers' understanding and efficacy when planning biomedical vocabulary instruction?

- Which aspects of the intervention affected teachers' understanding and efficacy in planning biomedical vocabulary instruction, either positively or negatively?

Literature

The Role of Medical Vocabulary in Scientific Literacy

Vocabulary knowledge is recognized as an important factor in developing scientific literacy, linking students' language proficiency with their ability to understand and communicate scientific information (Cohen, 2012). Norris and Phillips (2003) describe scientific literacy as including both the capacity to engage with scientific texts (fundamental sense) and familiarity with scientific content (derived sense); these components are closely connected. Cervetti et al. (2012) provide empirical evidence for this relationship, reporting that students participating in integrated science and literacy curricula demonstrated greater improvements in science vocabulary, writing, and conceptual understanding than those receiving separate instruction. Fang and Wei (2010) similarly report that incorporating explicit reading strategies into inquiry-based science instruction produced measurable gains in middle school students' science literacy.

Ødegaard et al. (2014) emphasize that while integrating literacy into inquiry-based science instruction can effectively support students' conceptual understanding, this outcome depends on structured support for teachers, especially in facilitating the discussion phase, where students consolidate their knowledge by linking data to theory. Honig (n.d.) notes that teachers can support students' scientific language development by immersing them in rich, meaningful, and varied instructional experiences since vocabulary learning is a gradual, multimodal process where word meanings are interconnected, diverse, and context-dependent, and is best reinforced through repeated exposure and multiple teaching strategies. Halsey (2012) emphasizes that interactive techniques, such as using wikis, enable students to actively construct meaningful science knowledge by creating and editing glossary entries with peers. Students repeatedly engage with scientific vocabulary, shifting terms from passive recognition to active use, thus strengthening their conceptual understanding in science literacy.

English instruction is typically divided into English for General Purposes and English for Specific Purposes. English for General Purposes focuses on broad language competencies, while English for Specific Purposes addresses tailored needs in particular domains, such as medicine, and utilizes field-specific terminology and linguistic features (Dao & Nguyen, 2023). Medical terminology represents a specialized subset of vocabulary within healthcare, characterized by complex terms and distinct grammatical conventions, such as irregular pluralization, differentiating it from general English usage. Medical terms usually comprise roots, prefixes, and suffixes, aiding in meaning construction, although the system may present challenges for learners (Dao & Nguyen, 2023).

Schmitt (2007) suggests that vocabulary acquisition should be understood contextually. Dao and Nguyen (2023) point out that relying solely on word parts without contextual awareness may lead to misunderstandings. Supporting incidental vocabulary learning involves exposing learners to new words through varied instructional methods, including frequent use in the classroom and collaborative activities, which facilitate vocabulary acquisition via peer interactions (Schmitt, 2007). Discourse analysis within English for Specific Purposes often examines textual features and communicative objectives to inform curriculum development, drawing from Systemic Functional Linguistics—a framework analyzing language use in social contexts and for specific functions (Hyland, 2007). Del Moral et al. (2024) evaluated role-play as a method for teaching medical terminology, finding that it increases relevance and engagement compared to traditional lecture and memorization. Their study indicates that role-play may support identification, pronunciation, writing, and understanding of medical vocabulary.

Game-based Learning

Game-based learning is an instructional strategy that incorporates the interactive aspects of games to facilitate learning and skill development (Al-Khayat et al., 2023). It includes the integration of game elements, mechanisms, or design features into educational settings (Deterding et al., 2011). Game-based learning differs from gamification, which applies game mechanics, such as points or badges, in non-game scenarios to promote engagement, rather than embedding complete games into coursework. In this learning approach, educational content is combined with gameplay to strengthen learning outcomes and connect concepts to practical situations (Pesare et al., 2016).

Several elements contribute to effective game-based learning. The approach draws upon cognitive, metacognitive, and memory strategies to deepen engagement with subject matter (Dodigovic, 2018). Thornbury, cited in Dodigovic (2018), identifies principles for effective vocabulary games, including repetition, memory retrieval, use in productive tasks, spaced practice, visual associations, and personalization, all of which aid knowledge retention. Game—based learning environments often employ visuals, sounds, and colors to maintain learner attention (Al-Khayat et al., 2023). Many game-based approaches encourage teamwork and social interaction. The design typically accommodates error-making, positioning mistakes as opportunities for learning rather than as failures (Adipat et al., 2021).

Vocabulary learning games can align with cognitive constructivism or socio-cultural learning theory (Dodigovic, 2018). Cognition-oriented games focus on individual problem-solving, while socially oriented games promote collaborative knowledge construction. For instance, crossword puzzles and simulation games are examples of cognition-focused activities, whereas Pictionary and many board games emphasize social interaction. Cognition-oriented games may suit analytic and introverted learners, while socially oriented games are sometimes preferred by extroverted learners.

Game-based learning in classrooms has been associated with increased motivation, engagement, and the development of critical thinking and social skills (Adipat et al., 2021; Jain et al., 2022). It enables exploration of solutions and encourages experimentation and risk-taking in open-ended activities (Nadolny et al., 2020). Rewards and incentives help maintain student attention, and some games allow self-paced learning. The described skills are considered relevant to 21st-century education.

Not all games are equally effective for educational purposes. Careful alignment between game design and instructional goals is necessary for the successful implementation of game-based learning (Hainey et al., 2016). Educators should select games that align with learning objectives, provide suitable scaffolding, and offer guidance to maximize learning benefits. Teacher expertise and ongoing support are important for effective application (Jain et al., 2022). Games should gradually increase in difficulty to sustain engagement, and debriefing sessions should link game experiences to real-world learning. Continuous monitoring and evaluation of activities are recommended to ensure alignment with intended learning outcomes.

Method

Educational action research, rooted in the work of Lewin (1946) and Collier (1945), aims to improve social conditions, particularly in schools. It combines practice, critical theory, and social change (Newton & Burgess, 2008), with a focus on classroom relevance and applicability (Mertler, 2019). This inquiry-driven approach integrates action and reflection to adapt to evolving social realities (Stringer, 2019).

The action research process is distinguished by its cyclical and iterative structure, frequently depicted as a spiral comprising recurring stages. While various models exist, most are based on Lewin's (1946) original framework, which begins with a planning phase in which a problem is identified and improvement strategies are developed. This is followed by an acting stage, where planned interventions are implemented. Subsequently, an observing phase involves the systematic collection of evidence and documentation of outcomes. The process then progresses to a reflection stage, emphasizing analysis of results, assessment of intervention effectiveness, and guidance for ongoing planning. This reflective cycle is typically repeated, progressively deepening the inquiry and enhancing both the relevance and impact of practice-based improvements.Using action research, we aimed to better understand teachers' experiences with our professional development program and apply these insights to enhance it in future versions. Our main goal was continuous improvement of the program.

Action Plan

Although there are many different models and approaches to teacher professional development, six common characteristics have been identified (Roehrig, 2023). These include 1) content-focused, 2) coherent, 3) active learning, 4) grounded in effective models of instruction, 5) collaborative, and 6) of adequate duration (Roehrig, 2023, p. 1199). This professional development intervention was guided by these five key principles of effective professional learning.

Coherence

This professional development program aligned with teachers' knowledge and state policies, and participation was voluntary. For Grade 7 life sciences, the program introduced game-based instructional strategies, supporting the Disciplinary Core Idea LS1.A and scientific literacy. The session used an everyday medical office context to address communication barriers and acknowledged teachers' prior experience with game-based methods in their classrooms.

Active Learning

During this professional development, teachers engaged in active learning, participating in collaborative, reflective, and inquiry-based practices. One of the key components was the "Medical Jenga" game, which was played in a way that addressed all the elements that contribute to effective game-based learning. They stacked and pulled the blocks labelled with biomedical vocabulary while explaining terms aloud. This simulation allowed teachers to experience firsthand how such games will turn out in their respective classrooms. They were also introduced to other medical terminology games like Organ Attack, Medical Terminology Bingo, DNA matching card games, crossword puzzles, and scramble games. Each game was briefly explained, allowing teachers to reflect on how the mechanics of the specific game will support their students' engagement. The teachers were given time to create their own game collaboratively.

Grounded in Effective Models of Instruction

This intervention was structured around established instructional models to ensure accessibility and foster teacher engagement. Participants were introduced to the theoretical foundations of game-based vocabulary learning, encompassing various types of vocabulary knowledge, assessment methods, activity components, and factors impacting effectiveness. Additionally, the workshop examined aspects of game-based learning strategies. It addressed related educational theories, such as cognitive constructivism and socio-cultural theory, highlighting how different games can be aligned with diverse student needs.

Collaboration and Collective Participation

During the in-person sessions, teachers were given time to collaborate with their peers and create classroom lesson plans that incorporated game-based strategies to teach biomedical vocabulary. The final day of the in-person component was dedicated entirely to planning.

Participants were given time to share ideas, collaborate, and begin developing their lessons. After the workshop, a smaller group was formed, and over a course of about one month, they continued refining their lessons. Two online meetings with the workshop facilitators were also set up to discuss their progress.

Duration

The professional development program took place over two months and included a one-week in-person event focused on teaching methods related to biomedical topics and cancer. Following the weeklong session, teachers received resources and time to create their lessons and collaborate in small groups and with program facilitators. During this month, two online meetings were held with workshop facilitators to monitor teachers' progress and provide support in lesson plan development.

Data Collection

The study employed a range of data sources—including surveys, exit slips, interviews, and observations—which were triangulated to evaluate teacher efficacy and experiences. The survey administered was an adapted version of the Science Teaching Efficacy Belief Instrument (Enoch & Riggs, 1990). Due to the sample size of 12 participants, the instrument's results were interpreted descriptively, with mean values informing the construction of subsequent interview questions. Qualitative analysis centered on self-efficacy, comprehension of medical communication, and critical thinking, utilizing recordings from professional development sessions and Zoom follow-ups to identify recurring themes and patterns.

Results

In What Ways Did this Intervention Impact Teachers' Understanding and Efficacy in Designing Biomedical Vocabulary Instruction?

The professional development improved teachers' understanding of effective strategies for planning biomedical vocabulary instruction. The following table provides a sample of questions and the corresponding results from the pre- and post-surveys, illustrating how teachers' perceptions evolved by comparing the means of both surveys.

Table 1. Pre-Post Survey Results: Teachers’ Efficacy in Teaching Medical Vocabulary

Question	Pre Survey Mean	Post Survey Mean	Mean Difference
I know how to use games to teach science vocabulary.	3.818	4.273	0.455
I am confident that I can teach about medical research effectively .	3.091	4.273	1.182
I am confident that I can design instructional activities to teach biomedical vocabulary.	3.455	4.636	1.182
I wonder if I have the necessary skills to design game-based strategy to teach biomedical vocabulary.	3.182	3.727	0.545
I understand how to help students retain challenging biomedical terms.	3.455	4.455	1.000
I know what to do to increase student interest in medical research pathways.	3.000	4.273	1.273
I can identify what makes vocabulary learning engaging and effective for middle school students.	3.727	4.455	0.727
I can see now how I can make topics such as the tentative nature of biomedical science and innovation in the cancer field more engaging and learning based with the help of hands-on activities.	3.545	4.545	1.000

Overall, the program’s pre- and post-surveys covered personal teaching efficacy and outcome expectancy for teaching science. Questions on changes in attitudes toward teaching medical vocabulary were added to section 1, which assessed teachers’ confidence and skills in using effective science instruction strategies to teach subject-specific vocabulary. The figure below shows pre- and post-survey results for Section 1.

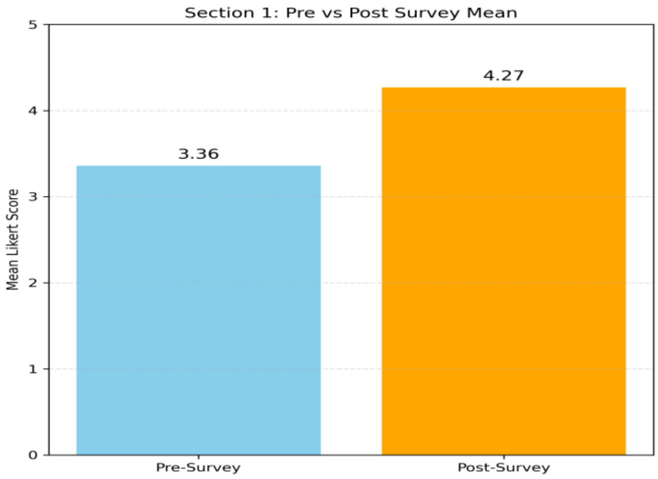

Figure 1. Section1: Personal Science Teaching Efficacy Results

Looking more closely into the qualitative data, we found that the teachers recognized repetition and memory retrieval as essential for learning biomedical vocabulary. They recognized how game-based learning reinforces this by describing their appreciation for "*the engagement and repetition that games provide*" and noting how games support "*repetition, application, and being able to see it in multiple ways*". Teachers also highlighted the "*quality of the game, retrieval of memory, repetition and fun*" and that the activities were "*low-stakes, repetitive practice*". Teachers also showed an increased understanding of how game-based learning can be adapted to support diverse learners, saying that "*The game-based learning will reach different types of learners (visual, auditory, kinesthetic, etc".* They also valued the physical engagement some games provided by noting "*Physical engagement and movement (such as games like giant Jenga)".* These reflections suggest teachers have an improved understanding of the elements of effective vocabulary activities and the merits of adopting a game-based strategy for vocabulary instruction.

The intervention also demonstrated a beneficial effect on teachers' ability to design and deliver biomedical vocabulary instruction using game-based learning strategies. Analysis of the professional development identified three key themes:

Increased Instructional Efficacy Through Practical and Engaging Strategies

Teachers reported feeling more confident in their ability to teach biomedical vocabulary effectively after being introduced to game-based strategies. The hands-on nature of the workshop, especially the Medical Jenga activity, resonated with them. They also appreciated the variety of games that were introduced to them through the workshop. The following quotes from teachers reflect this theme.

> *I especially liked all the different game ideas. I think the variety of options is very helpful (Exit slip response)*

> *Loved the group Jenga for vocab. I will work on getting/making several of the games (Exit slip response)*

> *I will use it with them to learn new vocabulary and in thinking about how medical practices have changed through time and why (Exit slip response)*

During the post-professional development meeting, four teachers came together as a group and shared their interest in incorporating different game-based techniques for their lessons. They adapted and modified the game-based strategies to fit into their classroom instruction. A few of their ideas are described below:

> *The major focus is kind of a case study lesson that [another teacher] can touch base on, but she's been doing a lot of work with mining standards and things like that. We've also come up with the Jenga game to review some cell cycle vocabulary. On microscope basics, crossword. I've been taking the lead on that to think about how to introduce the idea of microscopes to kids. [another teacher] has a really fun Domino's game and also on sunscreen activity. So those are some of the big ideas we've been kind. (Online group meeting)*

Perceived Effectiveness for Student Engagement and Learning

Teachers connected game-based vocabulary instructions to higher levels of student engagement and learning. This also showed an increased confidence in them to reach diverse learners.

> *Students are active in their learning (Exit slip response)*
> *I like how they're low-stakes, repetitive practice. Students are excited by games and don't always realize that they're also learning… I felt like they were adaptable and*

easy to bring in to most classrooms in some way. (Exit slip response)

Yes, these are activity that can go from one class to another (Exit slip response)

They also emphasized how the activities can be adapted for various grade levels to better engage students, demonstrating both the flexibility of the games introduced in professional development and teachers' awareness of their classroom effectiveness.

> *Basic concepts, games, and things like that can be sort of used in a spiral kind of vertical way, where even at the high school level, having a game that's on par with middle school can still be great to review and refresh content and things like that. So. (Exit slip response)*

> *[another teacher] and I bought both being 8th grade. I think we can kind of if something's up above a level that we, you know, we can just take those words out or you know if the Jenga, if these words are not necessary we won't put those on there. Etcetera. (Online group meeting)*

> *Yeah, like, even for the crossword activity, like I've built in, like, OK, well, if you have high school students, you probably just could give the crossword in the word bank to them. And they could work on it right independently. And then I was like, for middle schoolers, I made a much more scaffolded activity where the teacher does a few of them. Together with the students and has a physical microscope and is pointing to the different parts, you know, then giving them independent time and then following up with like when they're struggling or they're having hard to define terms. So like it's just it's the same activity, but there's just like more scaffolds or more independents along this spectrum of middle to high. (Online group meeting)*

Clear Intent to Implement Game-based Learning in Future Instruction

The best evidence of increased instructional efficacy came from teachers' clear intent to adopt game-based learning in their classrooms. When asked how they would use the information, resources, and activities provided in the workshop in their practice, all twelve teachers said they would adopt the game-based learning strategies in their classroom. The following example quotes from teachers reflect such intentions.

> *I will be implementing more game variety. (Exit slip response)*
>
> *I will work on getting/making several of the games. (Exit slip response)*
>
> *I'll also think about how I can gamify more lessons to get students engaged. (Exit slip response)*
>
> *I plan to use the games in labs. (Exit slip response)*

During the allocated planning period within the professional development in-person session, four teachers collaborated to integrate game-based strategies into their instruction. Following this meeting, the teachers expressed clear intentions to implement game-based biomedical vocabulary lessons. One teacher, who primarily teaches online courses, indicated her plan to adapt these lessons for an online format, as reflected in the following quote.

> *I'm going to figure out how to adapt it for online, like a crossword puzzle set up to be done online. You know, I mean you can do that right away. Things like the Jenga activity… There's still the cool factor of doing it on Zoom and having the whole big stack behind me, and pulling off and having the kids answer. That's one thing I'm considering, but I'm also trying to see if there are flashcard games, like quizlet. (Online group meeting)*

What Elements of the Intervention Supported or Hindered Teachers' Understanding and Efficacy?

As this study aimed to inform and enhance the professional development process, it was necessary to examine various components of the program. Several elements were identified that influenced teachers' understanding and effectiveness. In this section, the results are organized according to four key principles of effective professional learning.

Coherence

All participants agreed that this workshop was consistent with their pedagogical philosophies, classroom contexts, and curricular requirements. The materials distributed during the session were regarded as both accessible and intellectually stimulating from an educational standpoint. One participant noted

> *I liked how easy they were to adapt into all different kinds of classrooms. I also like*

> *how they challenged us to think about our pedagogy as well. (Exit slip response)*

Other teachers also echoed this sense of alignment of the workshop content with the classroom by noting

> *Absolutely! I loved that they are easily integrated into the classroom and could be at any level. (Exit slip response)*
>
> *There were a couple of activities that align well with the 8th grade science teaching and a couple that can fit in perfectly with biology. (Teacher interview)*

Teachers noted that the game-based biomedical strategies fit curricular goals and classroom needs. The example quotes below illustrate this point.

> *Yes, they fit with my curricular needs and will be engaging to my students (Exit slip response)*
>
> *You could at least fit them in for a review day, if not just fill them in as an ending activity for a lesson. (Exit slip response)*
>
> *And then, as for game-based lessons, for me, that's more like a strategy or a tool or a process, and less like a common standard. I think increasingly we're having to think of using more tools like that with our students. As we can see that traditional methods are not connecting as much with this newer generation and that's perfectly fine because every generation has their own like connecting. (Teacher interview)*

A teacher suggested that including supplementary reading materials with the activities could be beneficial. She observed

> *I would want more of it, like even if it's case studies or more research .... But some abstracts or some summaries, that would be something that would be kind of cool, like to supplement. (Teacher interview)*

Active Learning

The participating teachers noted the structure of the professional development and the chance to participate in activities similar to those their students would encounter. For example, one teacher stated: "We did lab tours, participated in activities, and attended lectures. It was a combination of hands-on experience and time for reflection. Overall, I think it was beneficial." (Teacher interview)

Throughout the Medical Jenga activity, all teachers demonstrated active participation and sustained interest, with engagement reaching its highest point toward the conclusion of the game (observation notes 18:17 to 43:00). They expressed their appreciation for the workshop's active learning methodology. One participant noted,

> *I appreciated the game-based learning activities. (Exit slip response)*

Another teacher highlighted the personal value of the approach, stating,

> *I found the game-based learning effective because I learn best through hands-on experiences. (Exit slip response)*

The participants also noted that the active learning component enabled them to gain firsthand insight into their students' perspectives during such activities. One teacher reflected on feeling anxious while waiting for their turn, particularly when they were at the back of the line. They further considered the classroom management challenges that arise when engaging a large group—such as 24 middle school students—with only one game of Jenga available. After participating in these games themselves, the teacher observed that students can both enjoy the activity and effectively retain knowledge through the experience (Teacher interview).

These responses showed how active learning strategies increased teachers' engagement and also modeled effective instructional practices that teachers could carry into their classrooms.

Grounded in Effective Models of Instruction

Teachers identified game-based learning as both engaging and a purposeful instructional strategy. One teacher highlighted the value of games as low-pressure, repetitive practice, observing that students are motivated by the gaming format and may not always be aware they are also acquiring new knowledge (Exit slip response). Others commended the flexibility of the model to accommodate differentiated learning, recognizing its capacity to support various learner types, including visual, auditory, and kinesthetic modalities (Exit slip response). The adaptability of game-based activities allows educators to present content in diverse formats, enabling students to select approaches that best suit their learning preferences (Exit slip response).

Additionally, one participant noted that the discussion around anomalies presented during the workshop was particularly beneficial, especially in relation to language barriers faced by medical professionals and patients, as well as teachers and students (Exit slip response).

The reflections indicate that modeling instructional strategies during the intervention provides teachers with practical examples they may consider implementing in their own classrooms. One participant observed that the professional development content appeared more suitable for upper secondary educators and recommended modifying it to better address the needs of lower secondary classrooms, as demonstrated by the following example comment:

> *I believe this professional development is more tailored to grades 7–12 rather than 5–9. This is intended as feedback for future sessions. (Exit slip response)*

Collaboration and Collective Participation

Teachers valued the opportunity to collaborate with other teachers during the professional development program. During the planning day of the program, four teachers collaborated as a group to adapt the game-based lessons to their classrooms. They were highly engaged in the planning process and thoughtfully modified the game-based strategies to align with their instructional contexts. The following comments reflect their experience.

> *Yeah, it was absolutely beneficial because, you know, we had the broad category of gamifying cancer research, medicine, all of the above. But I came up with maybe one or two activities and then kind of hit a roadblock. So it was really nice having three other perspectives to also bring in activities and ideas, or else I would have been doing the whole lesson planned by myself trying to figure out. (Teacher interview)*
> *I think when you work with other teachers. You just get reminded of how many really intelligent really dedicated people work in the profession and just the amazing stuff you can do with other teachers like this would have taken me 3 times the length by myself. But with other teachers were able to create all these different things. (Teacher*

interview)

Well, I love it because you know, for me it's kind of I'm in a unique situation where at my school I'm the only one that teaches 8th grade science. And so I think it, you know, it's beneficial for me to work with other educators that are in the that's teaching the same grade and that's what I found was beneficial to to to me, for me personally. (Teacher interview)

For the most part, my experiences aren't necessarily unique, so expressing concerns about I have a more difficult class with 25 kids in it and they don't have high attention spans and they don't want to do their work. And then. The other educators in my group were like, yeah, well, we experienced this too.

In the post-program interview, four educators offered suggestions for enhancing the program. One educator recommended initiating group planning at the beginning of the program rather than waiting until the final day. This recommendation was presented as an opportunity for improvement in future iterations, rather than a critique of the existing structure. The educator noted that early group formation could facilitate ongoing collaboration throughout the week, with Friday dedicated primarily to planning. Such an approach may support participants in reflecting collaboratively on lessons and activities with their designated teams.

Duration

The extended professional development provided teachers with ample time to plan and prepare their lessons. Five days of in-person sessions, two months of collaboration, and follow-up online meetings enabled teachers to confidently and effectively implement the lessons in their classrooms. Teachers appreciated the duration and the structure of the program, but also acknowledged the difficulty in collaborating online after the program, which is reflected in the following example quotes.

So I feel like the time of the week-long PD was sufficient. I mean, it's definitely more than you get. I think afterwards it's always so difficult to schedule with people. So I'm just very empathetic with that. (Teacher interview)

One of the teachers suggested that it would be beneficial to have more required group meetings (online) and stricter deadlines for the group of teachers to meet.

As far as the actual in-person week goes, that was perfect. I think, just because life is busy, having more specific, more structured deadlines and dates that we do need to meet with our groups would have been a little bit more helpful. (Teacher interview)

Discussion and Recommendation

This study examined the effects of a game-based professional development program on middle school teachers' efficacy and understanding regarding biomedical vocabulary instruction. The results indicate that the intervention led to an increased intention among teachers to implement game-based strategies for teaching biomedical vocabulary. The professional development was structured according to recognized principles of effective learning: coherence, active engagement, instructional modeling, collaboration, and appropriate duration, which contributed to its outcomes. Prior research supports the importance of vocabulary instruction as a core component of science education for conceptual understanding and student engagement (Cervetti et al., 2012; Norris & Phillips, 2003). Participating teachers echoed these views, noting that game-based approaches could make vocabulary more accessible and responsive to students' varied needs.

Teachers reported higher instructional efficacy following the intervention. Data from exit slips and post-session meetings indicated a strong inclination to use game-based learning methods, which was evident in their lesson planning discussions. This suggests a shift toward viewing vocabulary instruction as interactive and purposeful, aligning with literature emphasizing the benefits of hands-on, contextually relevant instruction for comprehension and retention (Fang Wei, 2010; Halsey, 2012). Activities such as “Medical Jenga” enabled teachers to observe both the cognitive and social effects of game-based learning and consider the practical adaptations necessary for classroom implementation. Post-intervention support was provided to help teachers address these challenges. Teachers also explored the theoretical underpinnings of game-based learning, recognizing varying suitability across different contexts and learners, which enhanced their understanding of vocabulary acquisition processes.

Feedback highlighted areas for improvement, such as tailoring sessions for educators at different grade levels, particularly high school. This suggests that program developers should differentiate content to meet teachers' needs better. Participants expressed interest in ongoing collaboration and support, which was maintained after the intervention.

The findings suggest that a well-designed professional development initiative focused on evidence-based practices can enhance teachers' efficacy and instructional skills. By combining scientific literacy, biomedical vocabulary instruction, and game-based methods, this intervention supported vocabulary teaching as a means to improve learning and engagement within classroom practice.

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CONCLUSION

Chapter 10 - Concluding Thoughts

Kristen A. Poindexter, J. Adam Scribner

Chapter Highlights

- This chapter draws themes across previous chapters in the book
- This chapter makes recommendations for future work incorporating reading strategies with science instruction

Introduction

Each chapter in this book presented teachers with strategies, actions, and lessons that can be used in elementary classrooms. Integrating literacy and science is increasingly being recognized as essential in elementary education, especially as instructional time becomes constrained and content integration is considered a practical solution (Mahzoon-Hagheghi et al., 2018; Nesmith et al., 2017). Finding creative ways to include science in the science of reading ensures that students are receiving what they need to become successful readers and engage with critical science content. Elementary teachers can take the core ideas from each of these chapters and scale them to meet the standards and needs of students in their classrooms.

The Reading League defines the science of reading as, "a vast, interdisciplinary body of scientifically-based research about reading and issues related to reading and writing" (2021, The Reading League). It is important to note, however, that the science of reading is not a framework or curricular materials. Instead, it is an evolving body of research that informs our practices about teaching children how to read and write. The science of reading includes: phonemic awareness, phonics, fluency, vocabulary and comprehension. Each of these components, when woven with the others, helps children grow into confident, fluent readers. When classroom teachers implement reading strategies, such as those presented in these chapters and those related to the science of reading, they can provide their students with the tools necessary to succeed in both literacy and science (Shelton, 2020).

The integration of science content and literacy is mentioned often throughout this book, specifically, utilizing science texts to help students learn important vocabulary and increase their level of comprehension. This strategy is effective with elementary students and with preservice teachers, however, it is recommended that preservice teachers have multiple attempts at the inclusion of science content in literacy instruction. Moreover, the integration of science and literacy must transcend the view that science texts function solely as introductory tools and acknowledge their value as texts that should be studied in their own right. Ultimately, this will lead to deeper understanding of science content and practical application of comprehension and vocabulary building strategies. Comprehension related questions should be varied as students interact with more complex vocabulary, allowing students to think beyond surface-level questions and gain a deeper understanding of the science content. Educators should be encouraged to use nonfiction texts alongside related fictional texts to demonstrate to students how comprehension and vocabulary strategies apply in both contexts. Additionally, instructors for preservice teachers should model similar strategies for their students and allow their students to practice developing their own lessons.

Vocabulary and comprehension was emphasized all through this book. Specifically, it was emphasized that vocabulary knowledge is one of the most important language skills a student can learn, with direct ties to their comprehension of text (Dickinson et al., 2010). Several chapters addressed the inclusion of vocabulary in lessons with both students and preservice teachers. In each study, selected vocabulary was related to comprehension, allowing students to learn either science-specific vocabulary or vocabulary that was situated in the context of a children's book, such as the vocabulary from Jack and the Beanstalk. The selection of these specific vocabulary words was intentional as it helped students make meaning of the text or science concept being emphasized, helping to increase student comprehension. This includes a whole chapter dedicated to examining how game-based learning can be utilized as an effective tool in vocabulary instruction.

In this book, storytelling was also used as a vehicle for helping students engage with selected texts and helping students of varying ages engage in scientific issues. The use of narrative-based interventions allowed students to use oral storytelling, including specific vocabulary words in context, aiding in the growth of their academic vocabularies (Spencer et al., 2024). Written storytelling, or narrative writing, was examined as one avenue that could potentially allow students to use their comprehension of texts along with important vocabulary words and while also helping students to share personal - and often meaningful -experiences. Additionally, it was noted that younger elementary students can use their developing phonics and phonemic awareness skills to aid their own writing.

Writing in response to scientific content helps students connect their lived experiences and deepen their comprehension of the content being studied (Fulwiler, 2007, Paek & Fulton, 2021). Moreover, as students engage with science content, they may ask more questions to clarify their understanding. Therefore, it is important that teachers have the tools necessary to implement an inquiry-based approach to science teaching use of different types of questions - like those found in Chapter 4. Ultimately, as educators implement the strategies from this book, their students will become more scientifically literate, and ideally, may feel compelled to take action in response to the content they are learning. Writing and sharing their individual experiences and feelings about what they are learning in science will further their connectedness to science while simultaneously increasing their literacy and scientific literacy.

Throughout this book, there were many practical strategies presented that educators can use to include science content during literacy lessons, including the use of vocabulary to increase comprehension, storytelling, and responding to texts in writing. Teachers should consider these strategies as recommendations for successful integration of science and literacy content and utilize them to ensure that elementary students are receiving necessary skills to become scientifically literate individuals.

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The purpose of this book is to explore incorporation of science instruction into teaching reading strategies through action research. As such, we have several sections that we are including (1) Incorporating Science into Reading Strategies in the Elementary Grades, (2) Incorporating Science into Reading Strategies in Preservice Teacher Science Methods Courses, and (3) Incorporating Science into Reading Strategies into In-service Teacher Workshopsand Institutes. Prior to these sections we include a literature review of research on previous strategies used to incorporate science and reading into instruction.

Section 1-Elementary Science Teaching: We have two chapters in this section, both set in Kindergartenclassrooms where the reader can see how literacy skills can be developed from the youngest students through science. In Ms King's chapter adult volunteers and students used reading as well as scientific inquiry strategies to explore and learn more about penguins. In Dr. Poindexter's chapter children' s literature is highlighted as ways to improve science literacy with young students, as well as their language development.

Section 2-Preservice Science Methods Courses: We have three chapters in this section. In the first chapter by Dr. Poindexter explored how to prepare preservice elementary teachers to use reading strategies to support science knowledge development. The preservice teachers experienced the reading strategy inspired science lessons as models for what they could do in their future classrooms. In the Bartels and Boche chapter they shared how to be intentional and explicit in making science integrated with reading strategies. They recommend the use of reading strategies to aid in development of scientific literacy and emphasizing the strategies more than once to ensure that the preservice teachers will be able to conceptualize and use the ideas and strategies in their own classrooms. In the Markavage et al chapter the lead instructor explored how to use children's literature to aid elementary preservice teachers to incorporate literacy into science instruction. They hoped to make children's literature an important component of instruction, not simply a "hook" to get students interested in science.

Section 3-Inservice Teacher Workshops and Institutes: We have two chapters in this section that explores helping inservice teachers to use reading strategies to teach science. First, Scribner shares about using storytelling strategies to develop science knowledge and practical strategies for teaching these to students in an environmental workshop. In the Buck et al, study the focus was on supporting inservice teachers who focus on helping students use medial communication through gamification. Explicit insights are provided for incorporating game-based approaches in elementary and middle school levels.

As we can see from this variety of action research studies in elementary classrooms and with preservice and inservice teachers, reading strategies can be used to support science instruction. Indeed, science content knowledge can improve, and reading strategies can be used to support science learning. For elementary and middle school teachers, reading strategies can be a pathway to improving science learning through incorporating children's literature, game-based projects, modeling for teachers, incorporating story telling, and various explicit strategies that not only support science learning, but also development of language and language literacy skills. Supporting scientific literacy through language literacy can be done, and the chapters in this volume provide guideposts for how to create such interactive and interdisciplinary lessons to support student learning.

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