Preparing Preservice Teachers to Help Elementary Students Develop Persuasive Science Writing

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Abstract

To inspire change in the world, scientists must be agile communicators who can persuade different audiences around the globe. Persuasive science writing must reflect an understanding of how culture and language influence audiences in different ways. Examples of scientific writing designed for different audiences around the globe include pamphlets describing safe masking practices or public-service announcements about climate change. Preservice teachers must prepare the next generations of scientists to think of science content in conjunction with communication. This has created a high demand for university programs to prepare preservice teachers to teach elementary students how to create persuasive science writing. The International Science Text Analysis Protocols (ISTAP) teaching methodology was designed to help preservice teachers guide elementary students to develop tools for creating persuasive science writing. This article details how university programs may use ISTAP to support preservice teachers before, during, and after school placements. As linguistic and cultural diversity within science classrooms in the United States continues to expand, students will bring diverse resources into conversations centering on persuasive science writing. As university faculty guide preservice teachers through ISTAP, they are emphasizing diversity within science classrooms and supporting equity within STEM.

Introduction

The success of science education can be evaluated based on how societies use science to engage in decision-making (Roth, 2022). Scientists may impact people's decision-making by engaging with both disciplinary and nondisciplinary audiences. Scientists need to not only convince reviewers and journal editors that their work is significant enough to be published; they must also communicate scientific findings to nondisciplinary audiences in a manner that inspires audience action. Despite a lack of training in how to communicate science to nondisciplinary individual scientists must often convince different audiences about the benefits and consequences of actions (Brownell et al., 2013,). Examples of persuasive science texts directed to a lay audience include pamphlets describing safe masking practices to be used during a pandemic or public-service announcements describing the consequences of climate change. These examples demonstrate how scientists must be agile communicators who can persuade different audiences. The scientific community has begun

to recognize that scientists must communicate scientific findings using persuasive language to help nondisciplinary audiences make informed decisions, (Lindenfeld, 2021). Therefore, science education must prepare science students to create persuasive science writing.

Because scientific communities need to engage in persuasion, it is important to distinguish the differences between argumentation and persuasion. Argumentation is a skill that has received more attention within science education in recent years (Erduran et al., 2015). Argumentation is a discourse through which claims are constructed and evaluated in consideration of evidence (Jiménez-Aleixandre & Erduran, 2007). Persuasion is a speech act within argumentation theory (Walton, 2007) that is defined as the presentation of a stimulus that changes, shapes, or reinforces a response, with the response being a change in beliefs, values, or attitudes (Simons, 2001). As science teachers begin to prepare students to use science to influence decision-making, they need to incorporate instruction that focuses on more than just a claim–evidence–reasoning framework (Herman et al., 2022). Although there is value in helping students develop argumentation skills, science students must also be taught to investigate the value systems, emotions, and societal pressures that motivate people to act on or discard recently introduced scientific statements. Scientists frame the world in ways that the public may not yet have envisioned. Scientists can use persuasive techniques to inspire nondisciplinary audiences to act to either prevent or bring about a future that they cannot currently see. Science education has presented teaching methodologies that support the development of argumentation skills (Erduran et al., 2015); however, science teachers need more support in developing curricula that help students develop tools for creating persuasive science texts.

Persuasion Reflected Within Science Standards

Science standards and curriculum emphasize that science teachers must include instruction on communication and science writing within their classrooms (Clark et al., 2021; National Research Council, 2012; Shymansky et al., 2012; Tobin & Tippett, 2014). One Science and Engineering Practice that is frequently highlighted within the *Next Generation Science Standards* (NGSS Lead States, 2013) is “obtaining, evaluating, and communicating information” (p. xx). Science teachers must help students understand that communicating involves persuading. One example of this can be seen within the *Next Generation Science Standards* (NGSS Lead States, 2013) for kindergarten through second grade:

- *Topic:* “Interdependent Relationships in Ecosystems: Animals, Plants, and Their Environment” (p. 167)
- *Performance Expectation:* “K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment” (p. 167).
- *Science and Engineering Practice:* “**Obtaining, Evaluating, and Communicating Information**. Obtaining, evaluating, and communicating information in K–2 builds on prior experiences and uses observations and texts to communicate new information.

- Communicate solutions with others in oral and/or written forms using models and/or drawings that provide detail about scientific ideas." (K-ESS3-3). (p. 168)

A key element of this standard is the section that states, "communicate solutions that will reduce the impact of humans" (p. 167). This standard reflects the idea that scientists propose solutions to change the beliefs of others and impact human action. The "others" referred to within this standard may include individuals within vastly different social contexts. This suggests that science communication involves engaging with different audiences in different ways. To communicate solutions with others and change beliefs, students must consider the differences in how individuals living with water provided in Flint, Michigan may perceive the relationship between nature and human action differently than students living with water by Lake Erie in Ohio. Dorfman & Kenney (2021) describe the history of Flint's water supply by stating,

> When, in April, 2014, the city of Flint, Michigan switched its water source, anti-corrosion agents were omitted from water treatment to reduce costs. As a result of the caustic water, service lines were stripped of their protective inner layer[,] and lead leached into pipes, contaminating the water supply and exposing Flint's children to lead well beyond safety standards. (Dorfman & Kenney, 2020, p. 573)

In Flint, Michigan, the human actions that influenced the water supply were linked to the actions of emergency management officials and others responsible for ensuring the safety of the city's water (Kennedy, 2016). Yet when elementary students in Northeast Ohio investigated the quality of their local water in Lake Erie, they noted that both human trash and algae impacted the water supply (Recker et al., 2022). The human actions that influenced the water quality in Lake Erie were linked to individuals or corporations putting trash in the water (Recker et al., 2022). In these two cases, persuasion would be used differently in order to influence human behavior. Even among students in the same geographic areas, financial contexts can influence individuals' perceptions of solutions. To communicate solutions to different audiences, students need to reflect on the sociocultural contexts of different audiences. Considering how to persuade an audience helps scientists understand how solutions may be contextualized and influence the beliefs and values of others.

Some NGSS standards (NGSS Lead States, 2013) guide students to specifically recognize the needs of an audience for science. For instance, Performance Expectation "3-5-ETS1-1 Engineering Design" for Grades 3–5 states: "Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost" (p. 53). Within this standard, elementary students are asked to contextualize the engineering design as they construct a science problem that revolves around the needs of the audience and respects limitations within the context (such as materials, time, or cost). When teachers teach elementary students about persuasion, they are helping students

understand that science knowledge is designed to be shared with people and adapted within real-world contexts. Science writing can allow students to both formulate ideas and communicate. (Negretti, 2021,).

Because persuading others is such a critical part of science instruction, teachers at elementary, secondary, and high school levels must focus on helping students develop into scientists with the ability to persuade others (Hsin et al., 2016). To help students become scientists who are effective in persuading others, teachers need to help students investigate tools for persuasion in science communication. In the past three decades, researchers have started to develop a body of research dedicated to the area of persuasion and science (Carter, 2021). For example, Shahab et al. (2020) found that impactful persuasion within science textbooks was dependent on employing elements such as the use of engagement, attitude, and graduation systems to support claims or counterclaims. Doctoral students attempting to publish science and engineering content have been found to integrate a consciousness of audience into their writing (Negretti, 2021). Many researchers also argue that an understanding of genre allows science writers to purposefully manipulate and recontextualize genre to persuade readers (Beaufort & Iñesta, 2014; Tardy et al., 2020). More research is needed on how to prepare science teachers to help science students develop the ability to convince others through persuasive science writing.

University Programs Preparing Preservice Teachers

Teaching methodology is needed to support university programs that attempt to produce teachers who can help elementary students develop persuasive science writing. Students from elementary school to graduate school should be taught communication and science content at the same time (Brownell et al.; 2013, Lexis et al., 2021). Integrating science and literacy instruction has been found to support young elementary students as developing scientists (Clark et al., 2021). Universities need to provide preservice teachers with models and experiences that teach them how to integrate science instruction with reading and writing instruction in elementary schools. One approach that preservice teachers might take is to occasionally use a small part of science instruction time to explore existing science texts and how they persuade audiences. By analyzing these texts together with elementary students, preservice teachers can help students understand effective ways to construct persuasive science writing. Teachers and students may discover together small elements that may be used in persuasive science writing. The next generation of science teachers must begin to think of themselves as multidisciplinarians who think critically about science as they read, write, and make sense of the world (Fang & Coatoam, 2013; Miller & Czegan, 2016; Ortlieb et al., in press; Shanahan & Shanahan, 2012). This creates an increased need for university programs to use teaching methodologies that support a multidisciplinary approach within science classrooms.

Preservice Teachers and Cultural Diversity

As science teachers help students develop as writers of persuasive science texts, they must also consider that global audiences for persuasive science texts include a variety of cultures and languages. This requires that preservice teachers begin to understand how linguistics and culture can inform how scientists persuade. Many science classrooms contain students who speak a range of languages and are from a variety of cultures. Science teachers must recognize that elements of cultural, linguistic, and scientific understandings interconnect and coexist within a child at the same time. Standard 2 of the *2020 NSTA/ASTE Standards for Science Teacher Preparation* emphasizes that university programs must train preservice teachers to develop tools to address the overlapping elements of culture, linguistics, and literacy within elementary school students (National Science Teaching Association, 2020). University programs must then train preservice teachers to help elementary students develop into scientists who can persuade audiences in writing across multiple languages and cultures.

This article presents one approach university programs may take in training preservice teachers to develop linguistically diverse persuasive scientists. We describe a teaching methodology called International Science Texts Analysis Protocols (ISTAP) that university programs may use to train preservice teachers. The ISTAP teaching methodology presents ways that university programs can provide ongoing support to preservice teachers before, during, and after school placements each week. In their school placements, preservice teachers are encouraged to increase elementary students' ability to create persuasive science writing. ISTAP provides methods that university faculty may use to help preservice teachers to plan, implement, and reflect on instructional procedures and assessments used in school placements.

Within elementary science classrooms, preservice teachers should highlight tools that are effective in persuasive science writing. This requires having class discussions that focus on examples of strong persuasive science writing. Preservice teachers must also help elementary students recognize that culture and linguistic diversity inform how audiences are persuaded by science writing. Over time, as elementary students receive purposeful instruction, they can be guided to recognize and use tools to create persuasive science writing within different sociocultural. Some science teachers may struggle to understand how they should include reading and writing instruction within their science classrooms. To address this need, this article discusses how university faculty may help preservice teachers plan, implement, and reflect on instruction and assessments that teach elementary science students to create persuasive science writing.

Supporting Preservice Teachers' Use of Methodology

To strengthen the connection between methods discussed in university courses and the application of those methods in school placements, ISTAP should be used with preservice teachers before, during, and after school placements. To foster an interdisciplinary approach to teaching, we suggest that ISTAP be used with both science education majors and other

education majors. Within this article, we discuss the ways in which we have spent three years using the ISTAP teaching methodology with preservice teachers within university courses and school placements. Across semesters, a total of 102 preservice teachers in the elementary education program have been taught using ISTAP. As part of a comprehensive program, preservice teachers took part in an on-campus methods course designed to introduce preservice teachers to teaching methodologies that support scientific, mathematical, and narrative literacy development in elementary classrooms. The preservice teachers concurrently took part in a placement course designed to provide preservice teachers with teaching experience in linguistically and culturally diverse K–5 classrooms. The placement allowed preservice teachers to teach elementary students during course periods designated as science, math, and literacy blocks. University programs might consider requiring preservice teachers to simultaneously engage in both a placement and university course that focuses on supporting elementary school students as reading and writing scientists (Croce, 2020). The following sections describe how the ISTAP teaching methodology may support preservice teachers concurrently in placements and university coursework. By using the ISTAP methodology, instructors may help preservice teachers teach elementary students to become scientists who create persuasive science writing.

How Does ISTAP Prepare Preservice Teachers to Address Persuasive Science Writing in Elementary Classrooms?

Instruction that focuses on constructing persuasive science writing must be accomplished in two parts. First, elementary students need to be guided to analyze how science authors in a variety of countries have created persuasive science writing. Second, elementary students need to be encouraged to employ persuasive science writing tools within their own persuasive science texts. One approach to addressing these goals is to use international science literature in classrooms. International science literature has been used in science classrooms for decades (Edwards & Potts, 2008; Lee & Spratley, 2010; Nelson, 2014). Science teachers may now consider using international science texts to examine persuasion around the globe. For example, this can be accomplished over a series of small lessons (20 minutes each) in which preservice teachers and elementary students explore and discuss a series of international persuasive science texts. The focus of the class discussion with each international science text remains on the elements of the persuasive science text that help the author to convince audiences. After this discussion, preservice teachers may encourage elementary science students to consider using some of these same tools in their own persuasive science writing. In order to help elementary students develop their persuasive science writing abilities, we created the following lesson objectives.

1. Elementary students will analyze science texts from multiple countries to determine how science authors use persuasive science writing tools.
2. Elementary students will write, speak, and perform actions that communicate science in persuasive ways to different global audiences.

Preservice teachers need to be able to engage in several actions to encourage elementary students to create persuasive science writing. Preservice teachers need to know how to: (a) develop conversations with elementary students about the tools that authors use in different countries to create persuasive science writing, (b) promote connections between the choices of international authors within their persuasive science writing and the choices that elementary students make within scientific writing, (c) develop and use assessments that measure elementary students' understandings as to how to create persuasive science writing, and (d) reflect on instruction and make adjustments for future lesson planning related to the development of persuasive science writing.

ISTAP may be used in university programs to help preservice teachers develop the types of critical thinking necessary to complete these actions. Table 1 presents an overview of the stages contained in ISTAP. Below we will explore each step of ISTAP.

Table 1

International Science Texts Analysis Protocols (ISTAP)

Step	Descriptions of actions or dialogue in each step
Step 1	**Preservice teachers prepare for instruction with elementary students.** a. In the methods course, preservice teachers meet in small groups to examine international science texts and determine possible lesson plan objectives. b. Each preservice teacher selects a text and lesson plan objective to use during instruction in the elementary school placement for the following week. c. Preservice teachers each select assessments to use during instruction in elementary school placements. An emphasis is placed on multimodality. d. Preservice teachers create written lesson plans to be taught the following week during placements.
Step 2	**Preservice teachers teach and assess lesson plans in elementary school placements.**
Step 3	**Preservice teachers reflect on instruction and assessments.** a. In the methods course, preservice teachers reflect on instruction by examining recorded clips of teaching sessions. Students are first asked to watch recordings of classmates engaging in instruction during the school placements. Preservice teachers are provided with guided questions to facilitate their reflections. After examining recorded clips of their peers, preservice teachers are guided to examine recordings of their own teaching. Possible retrospective analysis questions: • How did the preservice teacher model examples of the lesson objective? • How did the preservice teacher discuss possible adjustments to the suggested strategy?
Step 4	**Preservice teachers design enrichment activities to be used in school placements.** a. In the methods course, preservice teachers plan enrichment activities to implement in their placement schools.
Step 5	**Preservice teachers implement enrichment activities in elementary school placements.**
Step 6	**Preservice teachers reflect on prior instruction of enrichment activities.** Possible retrospective analysis questions: • In what ways were the students observed communicating their understanding of how science authors attempt to persuade?

Step 1: Preservice Teachers Design Instruction and Assessments for School Placements

ISTAP allows instructors to help preservice teachers develop an approach to teaching children to design persuasive science writing. Within Step 1, preservice teachers design instruction and assessments that will be implemented in school placements the following week during Step 2. In Step 1, preservice teachers will start by developing their own understanding so that they are better prepared to plan lessons to be used with elementary students. During step 1, preservice teachers are first tasked with exploring international

science texts within the methods course. After the preservice teachers are divided into small groups, the instructor provides each group with an international text set (a group of children's persuasive science texts from three or four countries). After preservice teachers are allowed to freely explore the texts in the set, the instructor selects three different international persuasive science texts to use as models in front of the class. During this time, the instructor is actively modeling how to examine how a text is written and not necessarily focusing on the text topic or subject matter (Pytash & Morgan, 2014). During this modeling time, the instructor may start by focusing on the visuals or illustrations. Table 2 contains examples of some of the tools that may be introduced by the instructor during class discussions that highlight differences in illustrations and aesthetics in books found in different countries. The design of the illustrations within each international persuasive science text connects to the reader's values and emotions in different ways. Instructors can use some of the questions found in column one of Table 2 to demonstrate to preservice teachers how authors of persuasive science texts may attempt to persuade different audiences. For example, the illustrations of the books found in China, Italy, and the United States all take different approaches to using cartoon characters, realistic drawings, or stick figures. Preservice teachers might consider whether each tool may or may not be considered an effective element of a persuasive science text in different countries. This reinforces the idea that culture may inform the persuasive science writing tools used by authors.

Table 2

Lesson Objectives That Highlight the Ways That Different International Science Authors Persuade Using Visual Images and Aesthetics

	Text Origin		
	China	Italy	United States
Possible lesson objective questions	我们的身体 [translation: Our body] (Hédelin, 2012)	*Corpo Umano* [translation: Human body] (RL Gruppo Editoriale srl., 2009)	*Picture This! Human Body* (Hynes, 2013)
Are images photographs of real-life objects and people? Drawings of people? Drawings of cartoon characters? Drawings of objects? Images of geometric shapes and lines?	Color drawings of people and objects that are closer to cartoon characters	Dream like drawings of people and objects. Realistic drawings.	People are depicted in drawings as stick figures without faces
Are images presented as two-dimensional or three-dimensional?	Two-dimensional	Three-dimensional	Two-dimensional
How is action depicted in the images? Arrows? Straight lines?	Moveable parts that allow images of the body to be moved by the reader	Radiating lines and shades that resemble rushing air. Some use of arrows to show blood moving through a drawing of a heart.	Two dimensional arrows that are straight lines or curved arrows
What tone or voice is represented in patterns in font? Are there bold or italics characters? Are all caps used?	Liberal use of many exclamation points	Liberal use of exclamation marks	No exclamation marks. Subtitles are in bold. All caps are never used.
Do images show actions or events that are not usually depicted in other scientific literature in other countries?	• Pictures of a surgeon with a scalpel standing over a child on an operating table. • Realistic images of food digestion. • Images of a pregnant woman's bare belly as instruments are attached to her belly for a sonogram.	• Depiction of a cross section of a woman's stomach during various stages of pregnancy. • Image of a woman's body while giving birth.	Stick figures mostly represent ideas. The images are not realistic.

After discussing the visual images and aesthetics of different international persuasive science texts, the instructor may next choose to focus on the written text. The instructor may have a section of one of the international texts read aloud in the class. This can occur using an audio reading of the text by the author or a guest speaker may be recorded reading aloud a section of the text. One of the preservice teachers could also volunteer to read the section aloud. Depending on the cultural and linguistic backgrounds of the preservice teachers, the instructor may need to provide a translation of the section of the text read aloud. Numerous research studies have discussed options for instructors to navigate STEM content in multiple languages with students (Dewaele & Wei, 2014; García et al., 2017; Hua et al., 2019; Tai & Wei, 2020).

Table 3 present some options for lesson objectives that instructors may want to focus on as they discuss how an author uses persuasion in the written parts of a text. While preservice teachers engage in these conversations about science texts in the methods class, they are developing ideas for possible lesson plan objectives to teach in their school placements during Step 2. Table 3 explores three examples of tools that can be used in persuasive science writing: experiencing, evoking emotions, and suggestions for action. Preservice teachers should also be guided to look for other tools used by authors within persuasive science writing. Any new tools discovered by preservice teachers may be included in lesson plans. We will now present some examples that describe how we have modeled for preservice teachers the use of the persuasive science writing tool called ‘experiencing’ (see Table 3).

Table 3

Lesson Objectives That Highlight the Tools Used in Persuasive Science Writing

Possible lesson objective	Explanation of persuasive tool used by author	Example in text
Author helps the reader experience actions (experiencing)	Text: *Comment ça marche? Moteurs et voitures* [translation: *How Cars Work*] (Arnold, 2013) The author changes the perspective of the reader in order to persuade them. The illustrations place the reader inside the driver's seat of a car and surrounds them with all the devices in the front seat of the car. This allows readers to feel a sense of driving. This may be helpful later when the author discusses the benefits of electric cars. The author's use of the tool of "experiencing" may convince the audience to become invested in the act of driving, further increasing the audience's connections to the use of electric cars. This may convince readers to use cars that protect the environment.	« *Imagine-toi assis au volant d'une voiture. Tu as devant toi toute une série de boutons, de pédales et de cadrans. Certaines de ces commandes, comme par exemple le klaxon, sont d'un emploi facile à comprendre. D' autres sont beaucoup moins évidentes.* » (p. 6) [Imagine yourself behind the wheel of a car. You have in front of you a series of buttons, pedals, and dials. Some commands, for example the horn, are easy to understand. Others are much less obvious.]
Author evokes the emotions of the reader	Text: *Forêts Tropicales* [translation: *Rain Forest*] (Fullman, 2008) The author evokes the emotions of the reader to persuade them. The author appears to want the reader to develop an appreciation for certain aspects of a rainforest. This appreciation can translate into an effort to preserve these forests. The author conveys empathy and implies a responsibility on the part of the reader to understand how the world is changing.	« *Son habitat est aujourd'hui déboisé de façon si alarmante que cet animal figure sur la liste des espèces en voie d'extinction.* » (p. 5) [Its habitat is today being deforested so alarmingly that the animal is on the list of species going extinct.]
Author suggests actions for the reader	Text: *Tornados* (Simon, 1999) The author is attempting to persuade by directly suggesting actions. The author specifically describes how the reader may do something to impact the world or humans so that they may be convinced to take action.	"You don't have to worry too much in advance about tornados, but finding out when they are coming and knowing what to do is certain to help you if one strikes." (p. 31)

Note. French text was translated to English by the first author.

To model the persuasive science writing tool of 'experiencing', we have presented preservice teachers with an example taken from our teaching within bilingual first- and second-grade classrooms. The lesson focuses on the written text within a persuasive science book from France titled, *Comment ça marche? Moteurs et voitures* (translation: How does it work?: Engines and cars) (Arnold, 2013). The persuasive science writing tool of 'experiencing' involves allowing the reader to experience actions related to the topic (see Table 3). In this text, Arnold (2013) states, "Imagine yourself behind the wheel of a car. You have in front of you a series of buttons, pedals, and dials. Some commands, for example the horn, are easy to understand. Others are much less obvious" (p. 6, translated by the first author). By placing the reader in the car, the writer has shifted the reader's viewpoint from observer to participant. This may allow the reader to perceive the topic from a different perspective. It is possible that many young children have not sat behind the steering wheel of a car. The author's use of the writing tool of experiencing allows children to become more invested in the process of operating a car. Later, the author mentions, "With their charging stations in the street, electric cars are starting to spread in big cities" (p. 7, translated by the first author). After initially changing the readers' perspectives by involving them in the actions of a car, the author may find that the audience is more receptive to considering the use of alternative energy sources. This persuasive science writing tool slowly helps the author to develop a subtle argument advocating for the use of alternative energies. The audience of children may be more likely to consider the option because their perspective has been shifted and they are perhaps more invested in driving. If the author did not try to get elementary students

interested in the act of driving, the children might be less interested in using electric cars. This demonstrates how the act of communicating science to convince others cannot be separated from the science content itself (Shivni et al., 2021). By talking through our connections to the text, we model for the preservice teachers how the author may be using a persuasive science writing tool within the text. Preservice teachers may choose to use with their elementary students the same text that has been used as a model by the instructor at the university. Preservice teachers may also look for other international texts that use the same tool.

An additional example of how we model persuasive science writing tools can be seen when we display for preservice teachers the writing of the author of the children's science book *Corpo Umano* [translation: Human Body] (RL Gruppo Editoriale srl., 2009). We suggest that this author attempts to persuade by allowing the reader to experience actions. The author writes, "Can you imagine being able to become very small and enter the human body aboard a mini-spacecraft?" (p. 6, translated by the first author). Here the author is trying to shift the reader's perspective on the human body by bringing the reader up close inside the body. By helping to shift the reader's perspective, the author hopes to help the reader become more invested in the topic. This investment in the topic might later allow the author to convince the reader to change behaviors, such as developing healthy eating habits. The author writes later in the text, "Having a healthy liver is essential for our health. This is why we must avoid excesses in meals" (p. 22, translated by the first author). The author has carefully laid a foundation in which he asks the reader to become heavily invested in the body by pretending to travel inside. The reader, who now more vividly views what a healthy body does or does not look like, may begin to become interested in protecting the body. The author then suggests that protecting the human body is linked to healthy eating and drinking.

As students discuss their own personal connections to the author's use of a specific persuasive science writing tool, they may discover that not everyone in the class could be persuaded using the same tools. Because classrooms consist of members from different sociocultural contexts, individuals will connect in different ways to persuasive science texts. The purpose of class discussions is to begin to examine how texts persuade and how culture may impact the ability to convince readers in specific ways. While elementary students must begin to learn tools that help them convince the audience, they must also learn that people in different countries may be convinced in different ways. The use of international science texts during discussions helps to emphasize the point that authors around the globe may use tools of persuasion in different ways.

As an instructor models possible persuasive science writing tools, preservice teachers may develop ideas for focal elements within class discussions in placements the following week. The preservice teachers are then ready to select texts to use during their own instruction in school placements. Lesson planning begins with preservice teachers selecting a text from text sets distributed by the instructor. In order to plan a lesson objective, preservice teachers are guided to first ask themselves, "What persuasive writing tools did the author use in the

text?” Asking this question helps preservice teachers determine how this specific mentor text can be used to model persuasive writing tools. Sometimes preservice teachers need to examine a few texts over time in order to begin to recognize tools that help science authors create persuasive science writing. The preservice teachers determine a lesson objective, anticipatory set, lesson body, and assessments to be implemented in the placement the following week.

As we model for preservice teachers what a lesson may look like, we draw on our own work in elementary schools. We have included an example lesson plan that we share with preservice teachers in the Appendix. This lesson plan highlights another persuasive science writing tool: evoking the emotions of the reader. We begin with the anticipatory set, suggesting that preservice teachers may ask elementary students how authors of science writing persuade others. Class discussion centering on an international science text may then illuminate for students the ways in which authors persuade others. Preservice teachers may ask elementary students about the choices of the author or illustrator that were persuasive. During the body of the lesson, preservice teachers may then highlight for elementary students the idea that they can employ the same tools when writing persuasive science texts.

When designing lesson plans, preservice teachers may want to focus elementary science classroom discussions around the questions provided in Tables 2 and 3. For example, in bilingual first- and second-grade classrooms, we have highlighted sections of the book *Pleine Lune* [translation: Full Moon] (Guilloppé, 2010). The author is attempting to convince audiences to be aware of the dangers that a predator can introduce into an environment. Predators like the wolf may not be a friend to many but instead an animal to be avoided. This is an example of an author who is attempting to convince the audience to be aware of the danger of predators. We explain to preservice teachers that we started the discussions by having the students look at the pictures in the book and asking the following questions: « Que vois-tu? » [What do you see?], and « Qu’est-ce que tu penses? » [What do you think?]. Preservice teachers can then employ preselected questions, such as those in Tables 2 and 3, when reading the text aloud and encouraging discussion.

In addition to planning the anticipatory set and lesson body, preservice teachers must examine ways that they can assess elementary students’ connections to the lesson objective. We model possible assessments for preservice teachers by drawing on some of the work of the first author as she taught in French–English bilingual first- and second-grade classrooms in the United States (see Tables 4 and 5). After engaging in a lesson with the teacher, the elementary students drew their understandings as to how the illustrator used color and pattern to persuade the reader to be aware of the predator in the forest in *Pleine lune* (Guilloppe, 2010). Instructors should share examples of elementary students’ responses (such as those found in Tables 4 and 5) with preservice teachers. The goal is for preservice teachers to be inspired to use assessments that allow elementary students to express understanding in ways beyond just the verbal.

Table 4

Examples of Students' Verbal Responses to Assessments

Students' verbal responses in developing French	English translation
Il change de couleur, noir et blanc.	It changes color, black and white.
Les couleurs changent pour les animaux.	The colors change for the animals.
Il passe du blanc au noir.	It goes from white to black.
Cette page a des imprimés d'animaux noirs. L'autre page a des imprimés d'animaux blancs.	This page has black animal prints. The other page has white animal prints.
Le blanc. Ça change.	The white. It changes.
Les pieds sont grands, grands, petits.	The feet are big, big, small.

Note. French–English bilingual first graders' verbal responses describe how the illustrator of *Pleine Lune* [translation: Full Moon] (Guilloppé, 2010) designs the images in order to persuade audiences to recognize the dangers of a predator.

Table 5

Examples of Students' Written Responses to Assessments

Child's invented spelling	French translation	English translation
Le lone a brey de aneymal a aneymal a blonc.	La lune ouvre de animal à animal à blanc.	The moon opens animal to animal to white.
Eu nwar ea blonc. Eu la lomear ea pooret.	Eu noir et blanc. Eu la lumière eu pourrai.	Had black and white. Had the light.
Pein lune l'ananmle banc.	Pleine lune. L'animaux blanc.,	Full moon. The white animal.

Note. French–English bilingual first graders' written responses describe how the illustrator of *Pleine Lune* [translation: Full Moon] (Guilloppé, 2010) designs the images in order to persuade audiences to recognize the dangers of a predator.

When planning assessments to be used throughout Step 2, preservice teachers need to consider multimodality by asking students to draw, act, or speak. For example, when discussing the choices of the author in *Comment ça marche? Moteurs et voitures* [translation: *How Cars Work*] (Arnold, 2013), the first- and second-grade students were observed displaying their understanding of the tool of experiencing by standing up and demonstrating what it looks like to jump into a car and start to use some of the equipment. The teacher could then point out that experiencing something can cause an audience to change their perspective and later be more open to further suggestions by the author.

Step 2: Preservice Teachers Implement Instruction and Assessments Within School Placements

Lesson plans created by preservice teachers in the methods course during Step 1 of ISTAP are implemented during school placements during Step 2. Preservice teachers need to be made aware that elementary students may bring diverse cultural and linguistic resources into conversations centering on the communication of science. We recommend that preservice teachers record themselves teaching during Step 2 to support reflection during Step 3. Each week as preservice teachers return from placements to reunite with classmates in the methods course, the class can unpack what did and did not work in their planned instruction. . This reflection time allows instructors to grow along with preservice teachers in their understanding of the elements that contribute to a successful persuasive science writing lesson for elementary students.

Step 3: Preservice Teachers Engage in Retrospective Reflection

After preservice teachers teach their lessons in elementary school placements during Step 2, they will be given time in the methods course to reflect on their teaching. During the first 2 years of using ISTAP, 54 preservice teachers did not have access to recordings of their instruction during school placements. The preservice teachers instead had to use their own recollections of their instruction, along with elementary student data, to reflect on the lesson during Step 3. In Year 3 of the study, a total of 48 students have now been able to use recordings of their instruction to engage in Step 3. Watching a recording of their teaching allows preservice teachers to reflect on specific actions or dialogue. Within each methods class that directly followed a placement experience, the instructor displayed small clips from the teaching of a preservice teacher who had volunteered to share recordings of their teaching with the class. We recommend that instructors select recordings that highlight how elementary students bring diverse cultural and linguistic resources into conversations centering on the communication of science. Instructors can select one clip highlighting instruction from different preservice teachers in the class each week. Preservice teachers use the following questions to guide their examination of the teaching clip: “What did you notice? What did you wonder?” After the whole class views the recording, we separate preservice teachers into small groups to share their responses. After discussing the instructional choices of their classmates, preservice teachers are given time in the methods class to review recordings of their own teaching. The instructor then asks preservice teachers to turn to a classmate and discuss one strength in their instructional decisions and one adjustment that they would make in future instruction.

Steps 4, 5, and 6: Preservice Teachers Create, Implement, and Reflect on Enrichment Activities

Preservice teachers might consider ways that enrichment activities can give elementary students opportunities to engage further with international science texts outside of elementary science whole-group instruction (Step 4). Preservice teachers may consider creating class science libraries containing persuasive science writing previously introduced during science class discussions (such as pamphlets, posters, or books). Baskets of persuasive science writing are placed on the floor to create classroom science libraries. During extension activities, preservice teachers can allow elementary students time to independently look through science libraries. Elementary students may find within the science library science authors who offer models that inspire students' own persuasive science writing. After implementing extension activities in school placements (Step 5), preservice teachers are encouraged to return to a university course to reflect on the strengths and needs observed during extension instruction in the elementary school placements (step 6).

Suggestions for Managing Unexpected Results and Unforeseen Challenges

Preservice teachers may struggle to find time within elementary lessons to discuss the tools that may be used in persuasive science writing. We suggest that a preservice teacher does not have to engage an elementary class with a whole text. A small section of a text may be selected to generate discussion. In addition, assessments may include encouraging elementary students to draw or act out understanding in just a few minutes. After including these elements within three or four 20-minute lesson plans at the start of the academic year, preservice teachers may refer back to previous lesson objectives later in the year. For example, a preservice teacher might state, "Remember when the author of the Italian book on the body asked us to get in a spacecraft and explore the body. Maybe we can now do something similar as we ask our audiences to imagine a cigarette entering a mouth. Maybe in your drawings you can draw the perspective of the mouth as a cigarette enters it. What does it look like when the smoke and chemicals come towards you? Can we also show the perspective of the throat and lungs as chemicals break off and travel through the body? What does it look like if you are in the lungs and smoke and chemicals are coming towards you? Would that convince the readers not to smoke? Could we later convincingly write that it is important for the body not to smoke?" Elementary students could also be encouraged to show physical actions that could be seen in a television commercial or video that they design. Multimodality is then incorporated within the content. After initially dedicating a little time in a few lessons to highlight tools used in persuasive science writing, preservice teachers can then draw on these tools throughout the year.

Initially, preservice teachers may not think of science authors as agents of persuasion; however, as we have demonstrated in this article, authors of science texts for children sometimes attempt to convince their readers in both small and big ways. Future scientists need to focus on effective ways to communicate their ideas to others (Wack et al., 2021). Persuasive science writers need to convince others in order to have their suggestions

accepted by different audiences. This may not be easy for a preservice teacher to see in a text initially, but insights may develop during the process of talking with instructors and other preservice teachers.

Instructors also might not feel comfortable with their own understanding of how persuasive science writing tools can be found within science writing. We suggest that instructors who are new to this process to create an environment of discovery within their classrooms. We have presented lesson objectives and discussion questions in Table 2, Table 3, and the Appendix; however, it is important to foster preservice teachers' creativity within a constructivist environment. Although the instructor may present a few lesson plan models, preservice teachers should include their own ideas about the tools that persuasive science texts present to elementary student scientists. Together, instructors and preservice teachers may coconstruct knowledge. Because sociocultural contexts inform persuasive science writing, cooperative learning environments are essential to exploring the topic of persuasion. Because culture may inform how individuals are persuaded, it is difficult to create a generic set of elements that can be used to persuade across countries. This article suggests that teachers guide students through an examination of the differences and similarities in persuasive science writing across cultures. By reacting to persuasive tools used by science authors, elementary students can discuss how certain elements may or may not be effective in certain contexts.

Conclusions

When preparing the next generation of scientists, preservice teachers must make strong instructional decisions that help elementary students persuade audiences through scientific writing. ISTAP provides university programs with a method to teach preservice teachers to help elementary students develop their persuasive science writing skills. Elementary students must begin to learn to use tools that change, shape, or reinforce readers' beliefs, values, and attitudes. They must also learn that different people from different cultures may be persuaded in different ways. The use of international science texts within science classrooms helps to reinforce these points. Students will bring diverse linguistic and cultural resources into conversations focusing on the creation of persuasive science writing. University instructors can support equity within STEM by guiding preservice teachers through ISTAP.

Supplemental Files

Croce-Spence-Appendix.docx

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