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Reading and Writing Like a Scientist: Implementation of Disciplinary Literacy Strategies in a Middle School Science Classroom

Cameron K. Boyette
ckb16b@acu.edu

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Abilene Christian University

Abstract

This study examined what happened when disciplinary literacy strategies were implemented in a middle school science class along with the students' and teachers' perceptions of these strategies. The researcher implemented disciplinary literacy strategies that went along with the scope and sequence for seventh-grade science at the time of implementation of the study. She collected data through surveys, observations, and interviews with students and teachers. Data were analyzed through the constant comparative method and coding. When disciplinary literacy strategies were implemented, students showed compartmentalization of reading and writing to their ELAR classes. Teachers showed negative perceptions of their students' literacy abilities. The students overall had more negative perceptions of the strategies than positive while the teachers had overall positive perceptions of the strategies used. This led the teachers to come up with solutions for future use of disciplinary literacy in their science classrooms.

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"I thought this was science not English." Kellsie (all names are replaced with pseudonyms) made this comment to me while working on her reading and writing project over biomes and ecosystems. Barnett also joined the conversation stating, "This is science, not reading" along with asking me if I could do his writing project for him. Conversations like this came up with Barnett and Kellsie every time we did something in class that involved reading or writing. Kellsie had mentioned in the previous class period that writing was "too much work." The shared apathy and confusion between Barnett and Kellsie were characteristic of majority of our students.

From the beginning of the school year, I noticed generally negative feelings within the science classroom surrounding reading and writing, from both students and teachers. Students would give up when reading for more than a minute. Teachers would complain that students could not read at the level they were supposed to be at. Students would struggle to write complete sentences with capitalization, punctuation, etc. Teachers would complain that they could not read their students' work because of their lack of syntax. The cycle was endless.

The negativity surrounding reading and writing in our science classroom reminded me of a class I took during my undergraduate years called "Reading in The Secondary Context." Before the first day of this class, I had negative opinions surrounding teaching reading and writing as a science teacher. I did not understand how I would teach reading and writing. I went to school to become a science teacher, not an English teacher. After the first meeting we had as a class and reading the first chapter of *Do I Really Have to Teach Reading?* by Tovani (2004),

my opinions about teaching reading and writing took a complete turn. I started to see just how important it was to teach reading and writing in all subjects, not just English and reading classes.

Purpose

Middle school is generally a time where students begin to have different teachers for each subject and elective classes based on their interests, allowing them to experience multiple disciplines every day. During these classes, students are diving deeper than ever before into the specific disciplines, especially in science. Hamilton and Stolle (2016) state "each discipline has specific ways and means of … communicating" making learning and using scientific terminology like learning and using a new language (p. 31). As middle school is a time of transition, more research should be done on how disciplinary literacy strategies impact the middle school science classroom. Research is emerging on how disciplinary literacy strategies impact middle school grade levels and science classrooms. The purpose of this study was to observe what happens when disciplinary literacy strategies are implemented in a middle school science classroom. Through implementation, students learned the differences in reading and writing in a science classroom compared to other subjects. Along with observing what happened when the techniques were implemented, this study also gathered the perceptions of students and teachers regarding the strategies. My study aimed to answer the following questions:

Question: What happens when disciplinary literacy strategies are implemented in a middle school science classroom?

Sub-Question 1: What are students' perceptions of these strategies?

Sub-Question 2: What are teachers' perceptions of these strategies?

This study took place during my year-long clinical teaching placement for a graduate program in a West Texas city with an approximate population of 125,000 people. The majority

of the population's ethnicity is White. There are multiple private, Christian universities within the city. The school district has around 17,000 students, a majority of which are Hispanic. My placement was at Moss Middle School, made up of over 900 students in grades six through eight. Moss is one of four middle schools in the district and has the largest population of students. Over half of the students are of Hispanic heritage. The next largest demographic is Non-Hispanic/White followed by African American, two or more races, Asian, Pacific Islander, and American Indian. More than 70% of the students are considered economically disadvantaged.

Literature Review

In education, there is currently a shift from content area literacy to disciplinary literacy. Disciplinary literacy "focuses on the specialized ways of reading, writing, speaking, doing, and thinking in a particular discipline," understanding that "each discipline has its own ways of using texts" (Grysko & Zygouris-Coe, 2019, p. 485). Content area literacy is more focused on "identifying and teaching general literacy skills" that help the students understand what they are learning at a surface level (Grysko & Zygouris-Coe, 2019, p. 485). Disciplinary literacy is different from content area literacy in that disciplinary literacy aims for students to become "an 'insider' or expert in the disciplinary field" (Graham et al., 2017, p. 64). Disciplinary literacy in science is not to be confused with scientific literacy (Spires et al., 2018, p. 1408). Scientific literacy refers to understanding scientific phenomena while disciplinary literacy in science refers to "style, genres, and discourse conventions" within scientific literature (Spires et al., 2018, p. 1408). While there is some overlap of literary similarity between disciplines, disciplinary literacy in science is different in that it "requires knowledge of scientific terminology, synthesis of multiple sources, and analytical thinking" (Spires et al., 2018, p. 1408).

English teachers should not be, and are not, the only teachers that teach reading or writing. Tovani (2004) stated that if "English teachers are the only ones teaching reading, students aren't going to learn how to read different types of texts" (p. 25). Followed by this statement, Tovani (2004) gave the example of an industrial technology teacher attempting to teach students how to read poetry. The industrial technology teacher would not teach this form of literature, instead they would teach students how to read "directions and blueprints and whatever else students read in his class" because those are a part of his discipline (Tovani, 2004, p. 26). When the industrial technology teacher teaches his or her students how to read blueprints and when the English teacher teaches their students how to read poetry, they participate in disciplinary literacy. Graham et al. (2017) argued that the "purpose of disciplinary literacy is not to assert that every teacher should be a teacher of reading" in the traditional thought, but rather it emphasizes and embraces "the different demands a text places on readers and writers in the various disciplines" (p. 64).

Teaching disciplinary literacy is important at all grade levels and has various benefits. Disciplinary literacy calls for students to become experts in the discipline they are studying. To become experts of the discipline, they must mirror the practitioner of the discipline. Students become experts in science when they "mirror scientists' professional ways of thinking and working…developing both scientific content and literacy knowledge" (Ippolito et al., 2018, p. 93). Disciplinary literacy is not only beneficial in the classroom, but it also "pushes students to move beyond reading, writing, listening, and viewing" for the sake of homework and standardized tests (Hamilton & Stolle, 2016, p. 2). Spires et al. (2018) aimed to "define the construct and establish the validity of disciplinary literacy" (p. 1401). The team divided the disciplines of English language arts, science, history and social studies, and math into three types

of literacy: source literacy, analytical literacy, and expressive literacy (Spires et al., 2018, p. 1401). Source literacy focuses on the credibility of the author and claims being made in the literature. Analytical literacy focuses on analysis of data, graphs, models, etc. Expressive literacy focuses on rhetoric, style, voice, and figurative language (Spires el al., 2018, p. 1420). Science was categorized as both source literacy and analytical literacy, depending on the type of science. Life sciences were categorized as source literacy and physical/chemical sciences were categorized as analytical literacy. Based on their findings, Spires et al. (2018) suggested that curricula "be structured as discipline-specific literacies in both sixth-twelfth grade education and teacher education" (p. 1428).

Studies have been conducted in the elementary science classroom that support the ability to teach disciplinary literacy to younger students. Grysko and Zygouris-Coe (2019) studied disciplinary literacy for students in grades three through five science classrooms. They claimed that the science classroom "provides an ideal setting for developing and refining literacy skills" (Grysko & Zygouris-Coe, 2019, p. 497). Through writing frames, science notebooks, and teaching how to support a claim with evidence and reasoning, they found that "the elementary science classroom is a perfect context for students to explore and learn, explain the world around them, and learn how to read, write, speak, and think in ways that reflect how knowledge is developed in science" (Grysko & Zygouris-Coe, 2019, p. 497). Starting disciplinary literacy strategies early on in education and continuing to build on knowledge throughout the middle school years would be beneficial for students in all subject areas.

The National Center for Education Statistics found in 2019 that "approximately 65% of U.S. eighth-grade students [were] not proficient in reading," calling for the need for disciplinary literacy to be focused on in the middle grade levels (Folk et al., 2020, p. 49). Disciplinary

literacy in secondary science "may focus more on reading and writing complex texts, with particular attention to discipline specific academic vocabulary, language conventions, text structures, and deciphering visual representations" compared to elementary science that "might focus more on inquiry-based instruction, encouraging particular disciplinary habits of mind, and expanding our definition of what counts as 'text'" (Ippolito et al., 2018, p. 92).

Folk et al. (2020) provided the example of a "multimodal multigenre STEM text set" on the topic of bumblebees to support disciplinary literacy in the middle school science classroom (Folk et al., 2020, p. 56). A scientific study about "eavesdropping" on bumblebees while they pollinate plants was used as the anchoring text for this text set (Folk et al., 2020, p. 50). The anchoring text was a study of patterns of pollination published by PLOS in 2017. Other pieces of text such as videos of bees pollinating, a poem by Emily Dickinson about bees, and sections of the classroom textbook regarding the science behind soundwaves were used surrounding the anchor text. As a result of the implementation of this text set, learners were able to better interact with and understand the anchor text. Further, diverse learners began to gain interest in the topic of study, self-efficacy, and confidence. Folk et al. (2020) found evidence that supported "the need for disciplinary literacy skills and complex grade-level texts to support science learning and college and career preparedness" (p. 56). This study supports the use of disciplinary literacy in the middle school science classroom.

The students in my seventh grade, Pre-Advanced Placement science classes were struggling with reading scientific texts and writing in a scientific context, making disciplinary literacy strategies a relevant implementation for action research. Within the current research, I was able to find articles about disciplinary literacy, disciplinary literacy in middle school, disciplinary literacy in elementary science, and disciplinary literacy in high school science.

However, there was a gap in finding disciplinary literacy in middle school science. Disciplinary literacy "has been theorized at the K-12 level more than it has been researched," thus more research needs to be conducted on disciplinary literacy in the middle school science classroom (Spires et al., 2018, p. 1404). Graham et. al. (2017) stated that "middle school is a time of transition between learning general content area literacy strategies and discipline-specific literacy strategies," thus emphasizing the need for implementation of disciplinary literacy strategies in these grade levels (p. 78-79).

Methods

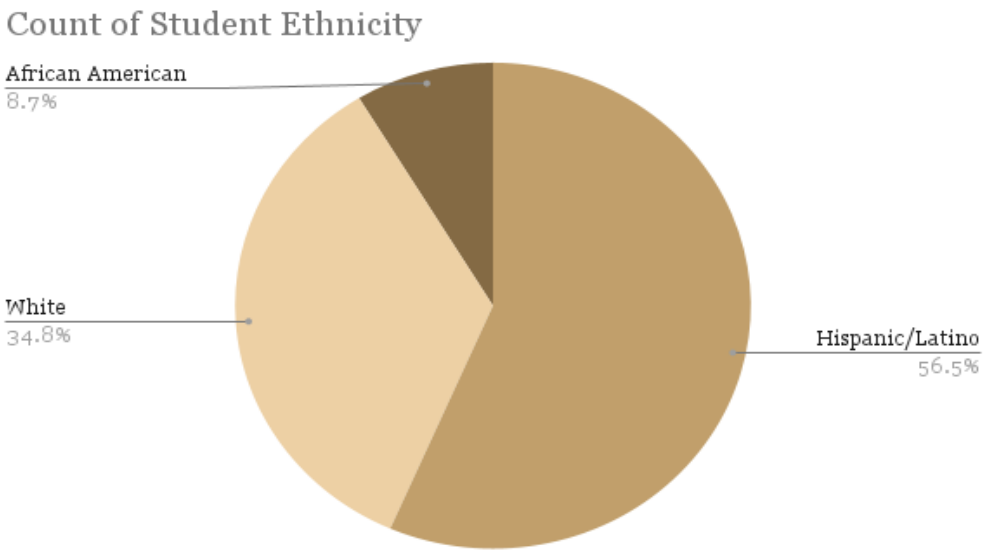
This action research study took place in the fourth and fifth period Pre-Advanced Placement classes for seventh-grade science. For two class periods, students were taught various strategies for reading (see Appendix A) and writing (see Appendix B) like a scientist. The information they were taught was obtained from a disciplinary literacy training written by Allender et al. (2020) for Annenberg Learner, an organization that provides free, online professional development for K-12 educators. The students used these newly acquired skills and applied them to a project over biomes (see Appendix C). For the next five class periods, students were divided into groups where they read articles about the different biomes and completed a project over the same biome. Data collection methods included a student survey completed by the students at the beginning and end of the study, observations during days of implementation, and interviews with the students and teachers to gather perceptions. All data was qualitative and analyzed through the constant comparative method (Kolb, 2012) and coding (Tracy, 2013). No quantitative data was collected during the study.

Participant Selection

The student participants for this study came from the fourth and fifth period Pre-Advanced Placement seventh grade science classes. Only students that submitted assent forms and obtained parent permission through consent forms were included in the study. A total of 23 students submitted assent forms and obtained parent permission through consent forms. Two seventh grade science teachers were also included in this study to gain a teacher's perspective on the strategies after signing consent forms. One of the teachers was a 42-year-old male that has been teaching for five years after completing an alternate certification process. The other teacher was a 25-year-old female that has been teaching for three years after completing an education program at a local, four-year university.

Figure 1

Count of Student Ethnicity



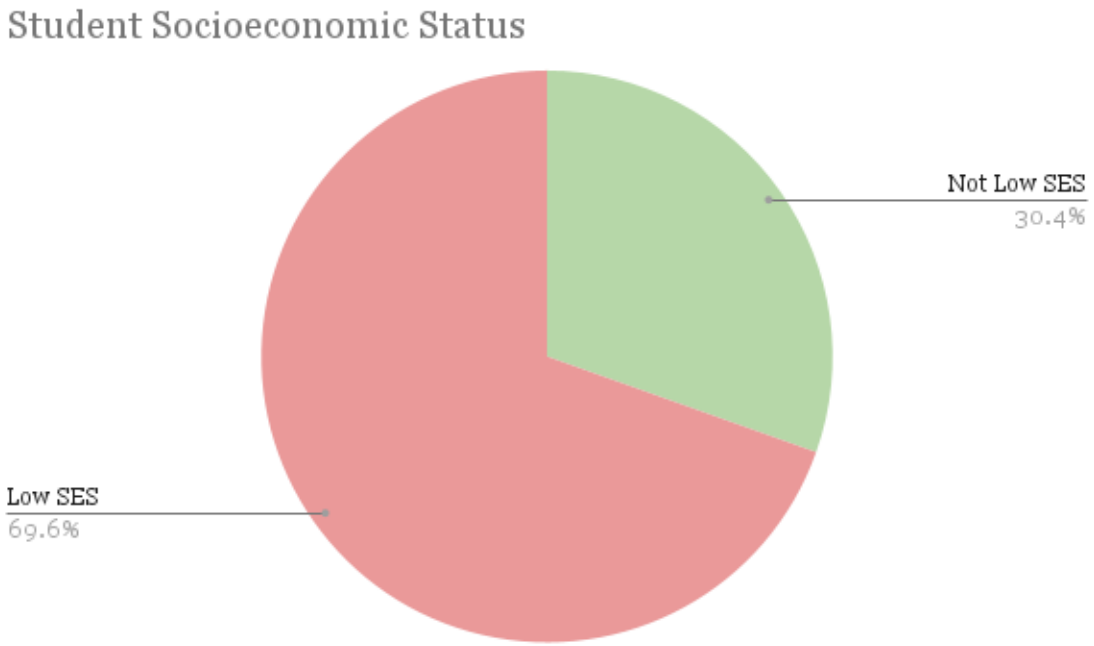
Note. This pie chart represents the ethnic distribution among the student participants of the study.

The following information was obtained from student records in the school district. The participant group in the fourth period class consisted of 12 students, seven of which were female

and five of which were male. Most of the students in this class were Hispanic/Latino White (see Figure 1). Eight of the students in this group were considered economically disadvantaged (see Figure 2), six of which were considered at risk for not graduating. Seven students in this group were a part of special populations. The fifth period group was made up of 11 students, three of which were female and eight of which were male. Most of the students in this group were Hispanic/Latino White (see Figure 1). Eight of the students in this group were considered economically disadvantaged (see Figure 2), seven of which were considered at risk for not graduating. Four students in this class were a part of special populations.

Figure 2

Student Socioeconomic Status



Note. This pie chart represents the socioeconomic distribution among the student participants of this study.

Data Collection

The collection process took approximately four weeks. Data were collected through open-ended questions in a pre-survey and post-survey completed by the students, interviews with two of the seventh-grade science teachers, a focus group composed of five students based on their survey responses, and observations made by the researcher during each class period. The students participated in disciplinary literacy strategies relating to the Texas Essential Knowledge and Skills (TEKS) indicated by the school district's scope and sequence for seventh grade science at the time of implementation of the study. The TEKS being covered during implementation were about ecosystems and biomes.

The student participants were given a pre-survey and a post-survey with questions about the topic of study, understanding of disciplinary literacy, and their perceptions on the disciplinary strategies implemented throughout the study. A pre-survey and a post-survey of open-ended questions were used to gauge their learning over the topic of study and how their perceptions of disciplinary literacy change, if there was any change, throughout the study. The pre-survey and post-survey consisted of the same questions and formatting to compare their knowledge of the topic of study before and after implementation along with how students' perceptions changed regarding disciplinary literacy (Hendricks, 2017, pp. 96-99).

Observations were made during each class period at the time of implementation. I looked for general signs of student engagement during the strategies along with use of scientific vocabulary when the students were speaking and within their scientific writing. Observations were made during the fourth and fifth class periods every day of implementation. While making observations, I took brief notes of words and phrases followed by expanding and fleshing out headnotes within a 24-hour window (Hubbard & Power, 2003, pp. 41-50).

The last form of data collection I utilized was interviews. Interviews were conducted at the end of the study. The interviews were "audio-recorded and then transcribed," as suggested by Hendricks (2017), followed by data analysis (p. 124). I held a group interview with two of the seventh-grade science teachers, lasting approximately 25 minutes long, asking about their perceptions of disciplinary literacy in science and the strategies that were implemented in the study along with what they observed in the classroom. I also held a focus group interview with five students, lasting approximately 15 minutes long, asking about their perceptions of the strategies they participated in. Students were chosen through purposive sampling for the focus group based on their responses in the post-survey (Hendricks, 2017, p. 11). From the post-survey data, I aimed to select an even mixture of students who enjoyed the strategies, were indifferent to the strategies, and who did not like the strategies.

Data Analysis

For my methods of data analysis, I used triangulation and the constant comparative method as recommended by Hubbard & Power (2003) and Kolb (2012). Triangulation was beneficial in this context because of the use of multiple sources to support the findings and rich database (Hubbard & Power, 2003, pp. 125-126). The forms of collection of qualitative data that were analyzed through triangulation were observation notes, surveys, and interview transcriptions. Observation notes were coded by hand with different colored highlighters. Coding is the process of "identifying, labeling, and systemizing data" (Tracy, 2013, p. 202). During the data analysis process, I generated 15 level 1 codes by coding the first 20% of my data, as suggested by Tracy (2013), followed by coding the remaining 80% of data with the same codes (p.185). After the level 1 codes were complete, I generated six level 2 codes. Level 1 codes focused on "what" was present in the data while level 2 codes grouped the level 1 codes

into categories (Tracy, 2013, p. 202). While generating codes, the codes were indexed using envelopes. A second set of the collected data was printed out to allow cutting and sorting manually into the envelopes. The envelopes were labeled with the level 2 codes (Hubbard & Power, 2003). Memos were created for each of the level 2 codes as a reminder of the meaning of each code (Tracy, 2013, p. 202). The codes were then placed in the form of a codebook (see Appendix D). Responses from open-ended surveys were coded by hand as well. The interview transcriptions were printed out to allow for coding by hand with different colored highlighters. The constant comparative method was utilized as it "is used by the researcher to develop concepts from the data by coding and analyzing at the same time" (Kolb, 2012, p. 83).

Findings

After spending time reading, analyzing, and coding the data, I was able to reflect on my main research question as to what happened when disciplinary literacy strategies were implemented in the middle school science classroom along with students' and teachers' perceptions of what happened. My data provided both positive and negative perceptions the students had of the strategies, positive perceptions the teachers had on the strategies, negative perceptions teachers had regarding the students' abilities in the strategies and showed how students have compartmentalized reading and writing to their English and reading classes. By the end of the study, the teachers' involved began to brainstorm how they could better implement disciplinary literacy in their future classrooms.

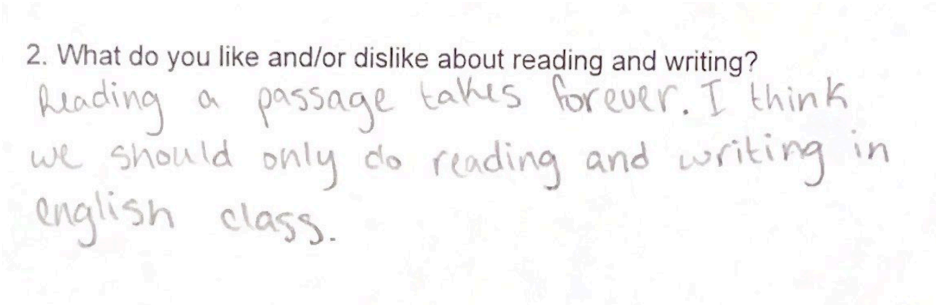
Compartmentalization of Reading and Writing to ELAR Classes

Throughout the study, I noticed that students had compartmentalized reading and writing to only occur in their ELA classes. Along with this compartmentalization, I noticed students that were not able to differentiate reading and writing between their ELAR class and science class.

While some students were not able to differentiate reading and writing between their ELAR class and science, others noticed the differences over time. During my observations, multiple students made the comment that we were in science, not ELA, and that reading and writing should only happen in their ELA classes. One specific student, Mabel, did well on her work, stayed on task, never verbally complained about reading or writing, but wrote on her pre-survey "I think reading and writing should only happen in English class" (see Figure 3) and on her post-survey "This is NOT English" (see Figure 4). Mabel expressed these feelings from the beginning of the study. I expected that her perceptions would change by the end of the study, but they did not. Her feelings actually became stronger when it came to reading and writing outside of her ELAR class. Mabel was not the only student to express these feelings, but her responses were the most blunt and explicit, making them an important addition to this manuscript.

Figure 3

Mable's Survey Response

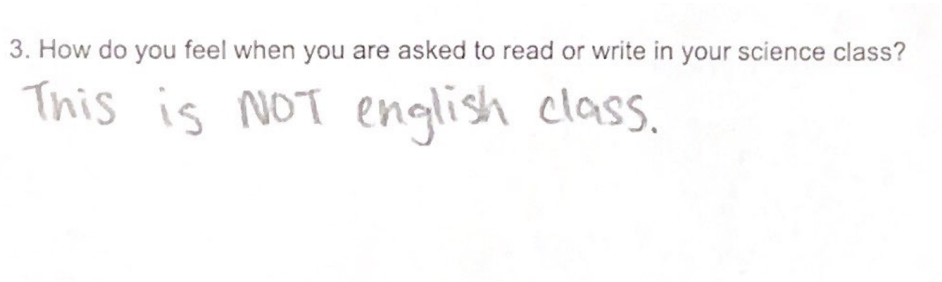


Not only was this theme made apparent in the survey responses, this theme was also found in the student focus groups, observations, and teacher focus group. The compartmentalization of reading and writing to ELAR classes makes sense because of the lack of disciplinary literacy in this specific setting. The students believed reading and writing should only be taught in their ELAR classes because that was the only class where they were working

on reading and writing. This compartmentalization will continue until disciplinary literacy strategies gain more attention and are implemented more frequently in the classroom.

Figure 4

Mable's Survey Response



As described in the methods section, students took notes on the first day of implementation about reading in science. Before we began the notes, the class discussed how to read, different texts to read, and what similarities or differences they saw between reading and writing in science compared to ELAR or other subjects. From my observations during this discussion, two answers stood out to me. At the beginning of the discussion, Rob mentioned that reading in English class was the same as reading in science. Barnett said that you read informative texts in both classes. This was interesting to hear and I began to wonder how this view would change throughout the study. Toward the end of the study, some students began to see the differences in literacy across the disciplines, but there were still a smaller number of students that could not differentiate among the disciplines.

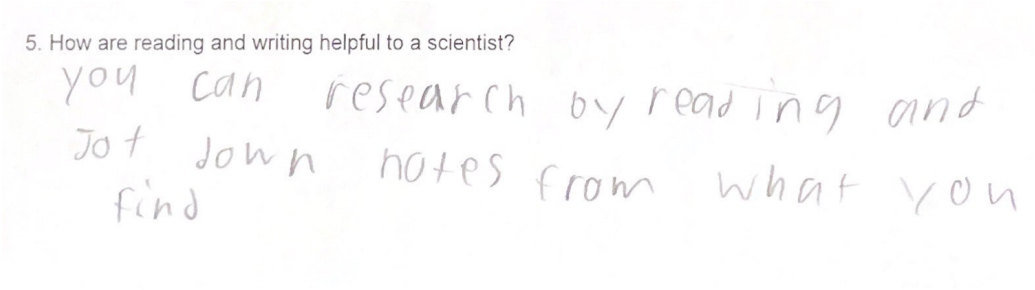
Positive Student Perceptions of Strategies

The students made general comments about sections of the work they enjoyed, but they were specifically positive about hands-on learning, understanding what the different sections represented in an academic journal article, and identifying how reading and writing are beneficial to a scientist (see Figure 5). This information was present in the observations, the surveys, and

the student focus group interview. Although the students had more negative perceptions of the strategies than positive, there was still enough positive perceptions to be significant to the findings.

Figure 5

Bailey's Survey Response



The main aspect students liked about disciplinary literacy was the hands-on experience it gave them. Before the implementation of this study, the only times students wrote were during fill in the blank questions or short, one-word answers to their daily bell ringers. Multiple students, specifically Harris during the student focus group, said they do not like sitting and listening in class, they would rather learn through doing something. Disciplinary literacy gives the students hands-on learning opportunities they desire. Whether it is through reading grade-level accessible research articles, following the procedures of a research experiment, or taking notes while observing scientific phenomena, there are multiple ways disciplinary literacy relates to hands-on learning.

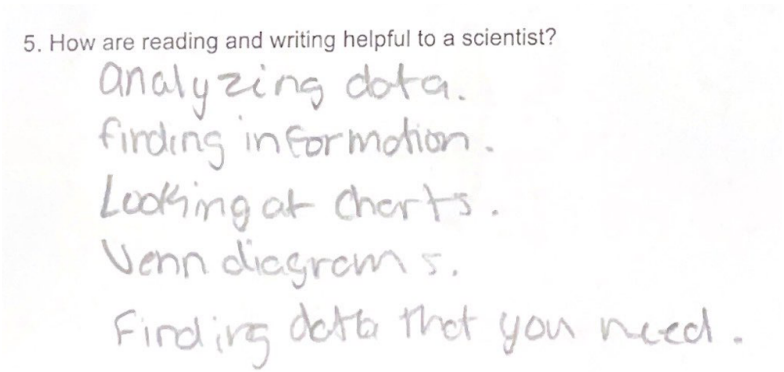
Throughout the study, students became familiar with the different sections of a scientific journal article by reading articles from *Science Journal for Kids*. On the last day of implementation, I had similar conversations with multiple students about the sections of a science journal. Each conversation started with students having questions and being confused on how they were supposed to complete their project. While explaining what was expected of the

students for the project, I also asked them verbally about the different sections of a journal article to see which ones they could identify along with the contents contained in each section. Every student I had this conversation with was able to identify what each section of a scientific journal article contained. This was considered a positive perception because of how the students reacted when they realized they understood each of the sections of the article. Their faces lit up, and they had an "a-ha" moment relating to a specific text that would be read in a science classroom setting.

Many students noted that reading and writing were used by scientists for taking notes along with sharing information with other scientists. The most common answer among the surveys was that reading and writing are helpful to a scientist because it allows them to share information with other scientists. Jade, by the end of the study, was able to acknowledge multiple ways in which reading and writing are helpful/used by a scientist (see Figure 6).

Figure 6

Jade's Survey Response



Negative Student Perceptions of Strategies

There were more negative student perceptions surrounding disciplinary literacy than there were positive perceptions. Common themes the students had surrounding disciplinary literacy that were negative were wanting the reading to be simplified, apathy surrounding reading and

writing, and using phrases like “I don’t know,” “I don’t like it,” and “This is boring.” This was a common theme that did not improve significantly throughout the course of the study.

During the student focus group and student surveys, a common theme was the idea of including simple readings, writings, and other disciplinary literacy strategies. The students thought the *Science Journal for Kids* was not simplified enough for the disciplinary reading. Some of the students thought the writing aspect of implementation was simple because it was only two paragraphs long. The consensus by the students for disciplinary literacy activities was that they should be easy and fun. This finding relates to findings found during the teacher focus group regarding starting disciplinary literacy strategies early in the school year and slowly building students’ stamina over time. This finding would have been different, maybe not even present at all, if the students had been building their stamina in this area starting at the beginning of the school year.

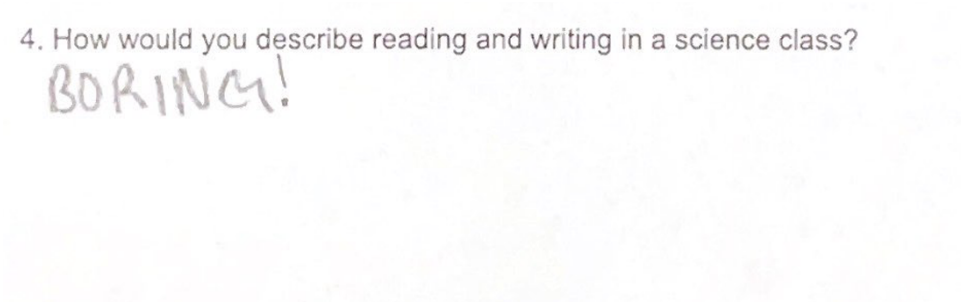
Apathy surrounding reading and writing was high, especially with Kellsie and Barnett. This was mainly found through observations and surveys. Every day when Kellsie and Barnett would walk into class they would complain about reading and writing and ask me to do their work for them. A common answer that would show up on student surveys was that writing “hurt their hand” and that reading and writing makes them tired. Makayla noted in one of her survey responses that the only reading she likes to do is on her phone. During one of my observations, I noted Edgar laying his head down when he was supposed to be writing because he did not want to do the work.

The use of phrases such as “I don’t know,” “I don’t like it,” and “this is boring” appeared the most throughout the survey responses before and after implementation of the study (see Figure 7). This was the most blunt response as to how the students perceived what they were

learning in class. These responses contributed mostly to the "students' negative perceptions of strategies" theme. These were phrases that were used even before the implementation of this study. These phrases are related and tie in with the apathy students experience towards reading and writing.

Figure 7

Mabel's Survey Response



Teachers' Positive Perceptions of Strategies

Teachers' perceptions of using disciplinary literacy strategies were overall positive, but they believed they had never used disciplinary literacy strategies in their previous science classrooms. The teachers that participated in this study gained a new perspective of teaching literacy in classes other than ELAR. One of the teachers involved in the study is certified for all content areas grades 4-8 but had not thought about literacy across the possible disciplines he could teach until this study.

The students were taught information about reading and writing in science from the disciplinary literacy training written Allender et al. (2020) for Annenberg Learner at the beginning and middle of implementation. When discussing the note taking portion of this study, both teachers believed it was necessary to include and that it was the best part of the study. Without the students receiving direct instruction, taking notes, and comparing the types of text they would read and write in a science class compared to ELAR, math, or history, the

students would have had a much more difficult time understanding the purpose of reading and writing in a science class. This aspect of the study is something they were most likely to include in their future teachings at the beginning of the year when the content lines up better. Mr. Smith believed he had never taught literacy in his class in previous years because he "assumed all kids could read by the seventh grade." Mrs. Lemon could only recall one time in her three years of experience where she had her students did some sort of writing like a research paper.

Based on my observations throughout clinical teaching, I think the teachers have included more disciplinary literacy than they realize, they just have not been explicit, as this study was, about how reading and writing are different across the disciplines. Both teachers acknowledged that they had not thought about the differences in reading and writing across disciplines until this study. As the study went on, they started to notice the importance of teaching disciplinary literacy and were always engaged in what the students were doing during implementation.

Negative Teacher Perceptions About Student Literacy Abilities

While the students had more negative perceptions about the strategies than positive, the teachers did not have any negative perceptions surrounding the strategies. In fact, they only had positive perceptions on the strategies, but there were negative teacher perceptions surrounding the students' behaviors when learning about disciplinary literacy than there was positive. Common phrases that came about during this section of research were that students were not capable of reading and writing for extended amounts of time and that students would rather copy and paste words rather than come up with their own writing. These combined to create a negative overall teacher perception of students' abilities.

Mr. Smith often said throughout the interview that students were not capable of reading and writing for long periods of time because they are no longer in elementary school and do not

spend as much time doing independent reading. With Mr. Smith's background of elementary education, his response makes sense. He was able to directly compare how reading changes from the late elementary to middle grade levels. Another common phrase Mr. Smith mentioned was the lack of focus and attention span students have now. This comment relates to his comments about students being incapable of sitting and reading for extended periods of time. Both Mr. Smith and Mrs. Lemon agreed that students were incapable of coming up with their own thoughts and ideas. This led him to the discussion of how teaching is not just about sitting and reading and that we know just reading and writing is not best practice for students. There must be a balance when implementing disciplinary literacy that is hands-on learning, which the students enjoy, rather than giving the students just a worksheet and calling it disciplinary literacy.

When talking about the reading and writing students did for this study, the teachers compared this assignment to a writing assignment we had the students do at the beginning of the year. At the beginning of the year, Pre-AP students were in charge of researching a disease or disorder of their choice and writing a research paper over it. They had to meet certain requirements and list where they found their information. A common practice that was observed with both writing instances was students copying and pasting word for word from their resources rather than writing information out in their own words. This finding supports the need for reading and writing to be taught in all disciplines, not just ELAR.

Teachers Come Up with Future Solutions

During the teacher group interview, Mrs. Lemon and Mr. Smith discussed how disciplinary literacy can be implemented better in future middle school science classes. The two teachers came to the consensus that implementation needed to be highly structured and start at

the beginning of the school year, slowly building stamina over time. Despite being discouraged by the students' performance throughout the study, the teachers still had positive perceptions of disciplinary literacy strategies and wanted to find a solution for future use. The teachers in this study examined what happened over the course of three to four weeks and thought about how they could be modified for the better for the future science classrooms they would have. This outcome was not surprising. Teachers are constantly trying new rules, techniques, projects, etc. in the classroom, observing how it works out, and changing for the next time to better fit their classroom. This is a prime example of action research, which is the type of study that was conducted.

As a response to the activities the students participated in throughout the study, Mrs. Lemon and Mr. Smith decided that implementing disciplinary literacy strategies requires a high level of structure and planning. Some common aspects Mrs. Lemon and Mr. Smith mentioned needing with disciplinary literacy strategies was checklists, rubrics, organization on Google Classroom, planning sheets, guided practices, working on only in the classroom, etc. Having a high-level of structure allows for disciplinary literacy concepts to be focused on better and for students to focus on only having questions about the topic in question rather than everything else going on.

In future school years, the plan would be to introduce disciplinary literacy at the beginning of the year and slowly increase the amount of reading and writing over time. This would allow disciplinary literacy to be applied to all scientific concepts taught throughout the year. In Texas, the Texas Essential Knowledge and Skills (TEKS) call for teachers to teach about the scientific method at the beginning of the school year. Mr. Smith and Mrs. Lemon

believed that adding disciplinary literacy into the curriculum at the beginning of the year would help carry the idea of reading and writing like a scientist in a consistent way.

Limitations

While I was able to collect plenty of data regarding perceptions of the students regarding disciplinary literacy, the perceptions were limited as they all came from students in the Pre-Advanced Placement science classes. Even though there is a diverse group of students in the Pre-AP classes, not having sampled the on-level classes left out some possible perceptions that were not observed in the Pre-AP class. As expected, the classroom proved to be a constantly changing environment. We had incidents of snow breaks, classrooms flooding, COVID shut-downs, a once-a-week sexual education course, etc. This led to lessons having to be moved around in the schedule, extending some due dates, and other small changes that may have had an influence on how the students understood the topic at hand. At the end of the study, I was wanting to have the students "speak like a scientist" and present their findings with their classmates, but we ran out of time. I also only had six students participate in the focus group interview. While every student that participated in the study filled out two surveys and were observed, not everyone was able to participate in the focus group interview.

Implications for Teachers

In summary, when disciplinary literacy strategies are implemented in the classroom, it is revealed how students have compartmentalized reading and writing to their ELAR classes. Students had both positive and negative perceptions relating to the strategies, with their being more negative perceptions than positive. Teachers only presented positive perceptions of the strategies but had negative perceptions of their students' abilities in literacy. When the strategies are implemented, teachers start to develop solutions and ways to implement disciplinary literacy

strategies in future classrooms. From this action research study, my students got a glimpse into the importance of reading and writing in all classes along with how they differ between the disciplines. I learned how to better implement disciplinary strategies in the classroom along with how important and necessary it is to teach disciplinary literacy in all disciplines.

The findings throughout this study support the need for more disciplinary literacy research, especially in science classes, along with how important it is to start teaching this topic at the beginning of the school year. While I already knew I would want to teach disciplinary literacy in my own classroom based on reading Tovani (2004), this action research study showed me just how much work goes into teaching disciplinary literacy. Throughout my career, my primary goal will be for my students to become experts in science through reading, writing, speaking, and doing.

As a result of this study, many new questions have emerged. First, how do we as educators end this compartmentalization of reading and writing to ELAR classes? My initial answer to this question would be to start implementing disciplinary literacy strategies in all classrooms, but this answer brings up another question. Second, how do we as educators gracefully transition from content area literacy to disciplinary literacy? Whenever there are changes made to the education system, educators have to fill in missing pieces before the changes being made will be beneficial for the students. Finally, what would happen if disciplinary literacy became a standard for teachers? In Texas, this question would be aimed toward the Texas Essential Knowledge and Skills (TEKS). Making disciplinary literacy a part of the TEKS for all subjects would have an impact on education as a whole, but what kind of impact would it have?

Advice for teachers moving forward in teaching disciplinary are to utilize the resources from Annenberg Learner and follow the suggestions made by the teachers throughout this study. The professional development training over disciplinary literacy that were used as a resource for this study are beneficial to all disciplines and all grade levels. Before focusing on disciplinary literacy with your students, use their information to get a full grasp on literacy within your discipline. When you begin to implement disciplinary literacy in the classroom, follow the suggestions of Mr. Smith and Mrs. Lemon by starting early in the school year, building up stamina over time, and having a high level of structure.

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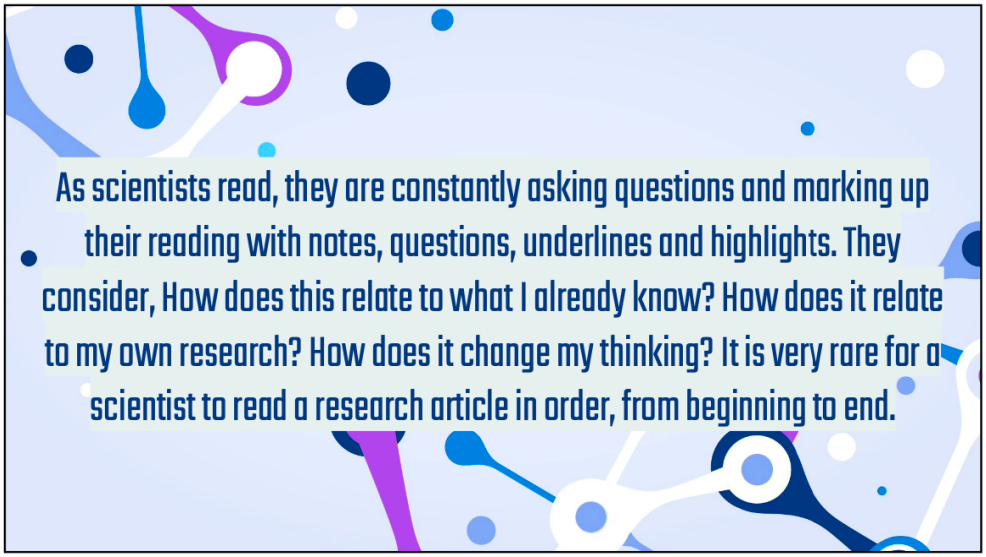
Appendix A

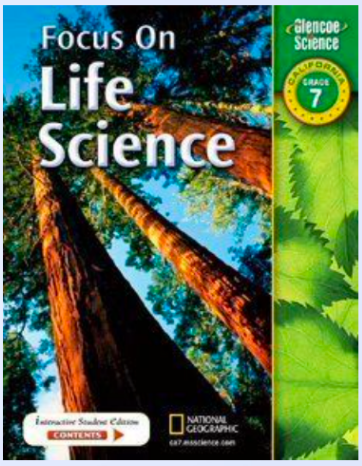
Reading Like a Scientist Slide Show



Materials You Will Read in Science

Textbook

A textbook is a book used as a standard work for the study of a particular subject.



Articles

An article is a piece of writing included with others in a newspaper, magazine, or other publication.


JUNE 2020

SCIENCE JOURNAL TEENS

How can we track life in the ocean?

Abstract

Introduction

Material Safety Data Sheets

A document that lists information relating to safety and health for the use of chemicals and products.


ScienceLab.com
Chemicals & Laboratory Equipment

Material Safety Data Sheet
Silver MSDS

Section 1: Chemical Product and Company Identification

Section 2: Composition and Information on Ingredients

Section 3: Hazards Identification

Section 4: First Aid Measures

Dichotomous Keys

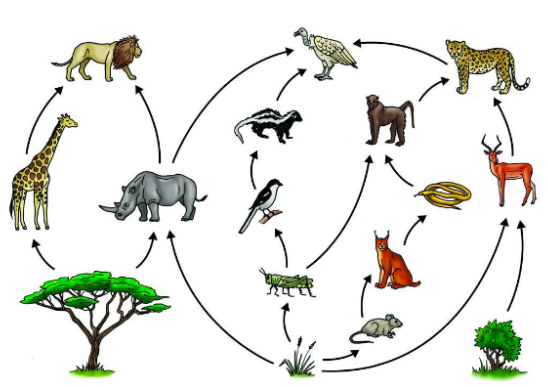
A dichotomous key is a scientific tool, used to identify different organisms, based the organism's observable traits.

Tropical Trees

1. Leaves are simple and flat.
   1a. Yes: it is a banana tree (*Musa lasiocarpa*)
   1b. No: go to 2
2. Tree is short and bushy.
   2a. Yes: it is a Mazari palm (*Nannorrhops ritchiana*)
   2b. No: go to 3
3. Leaves are palmate (fan) shaped.
   3a. Yes: it is a fan palm (*Washingtonia robusta*)
   3b. No: go to 4
4. Tree has a bulging trunk.
   4a. Yes: it is a bottle palm (*Hyophorbe lagenicaulis*)

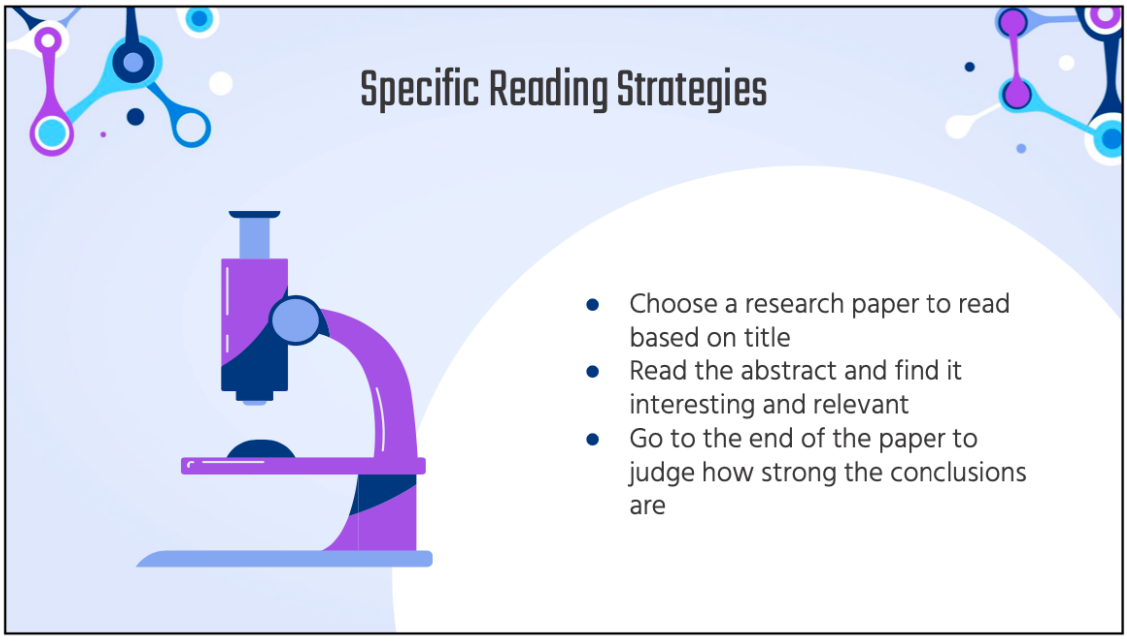
Food Webs

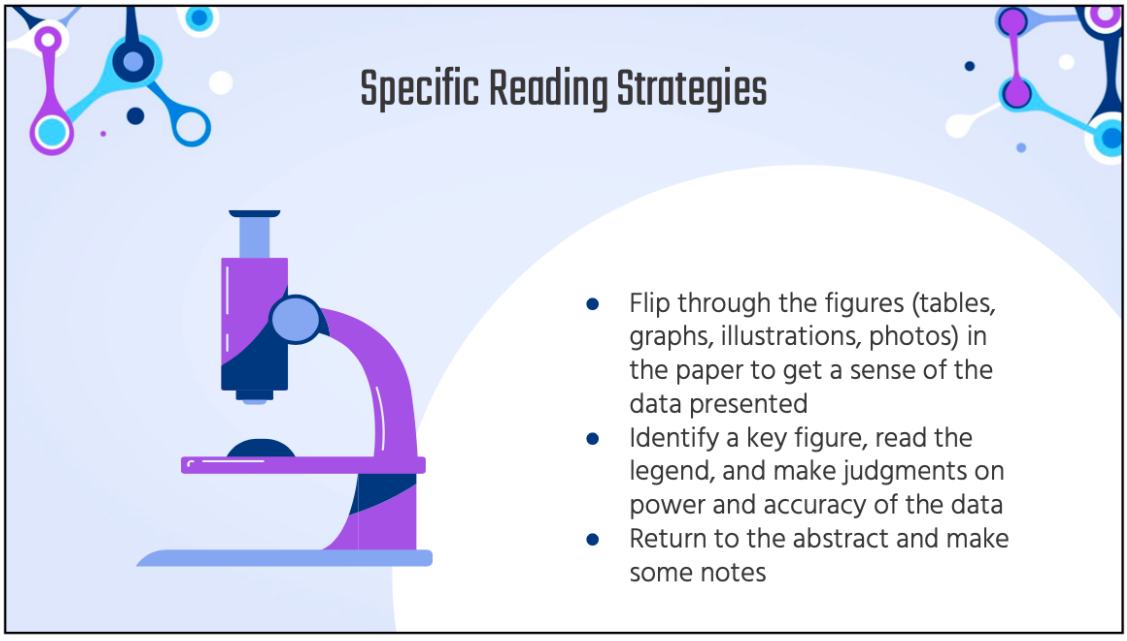
A food web is a system of food chains. It is a representation of what-eats-what in a community.

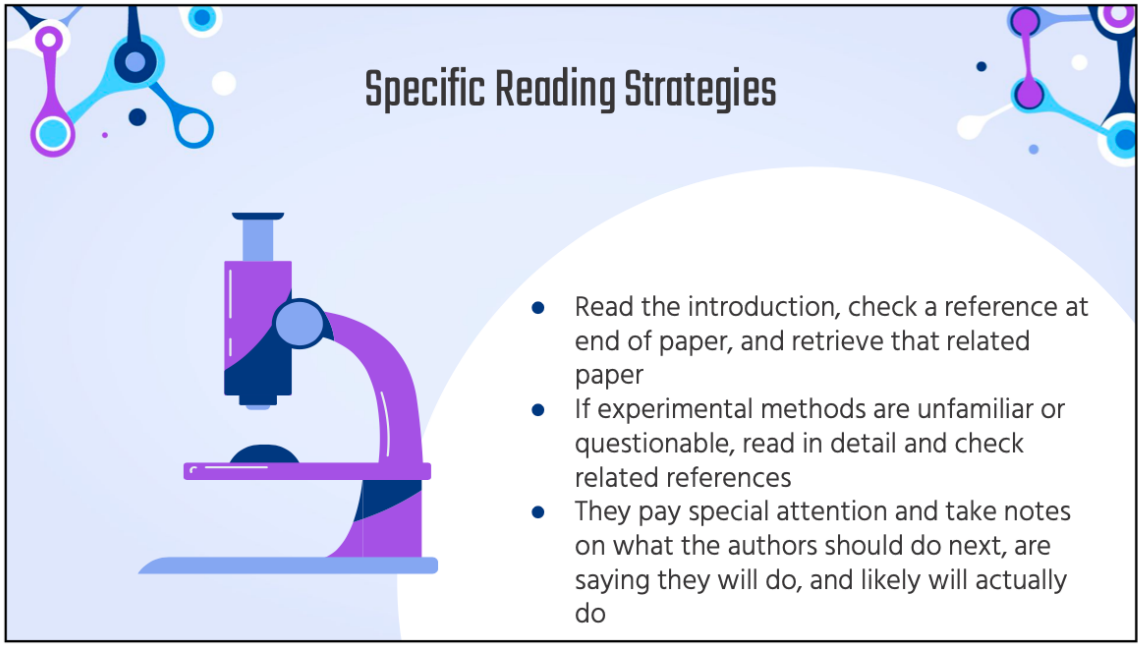



And so many more...


Specific Reading Strategies

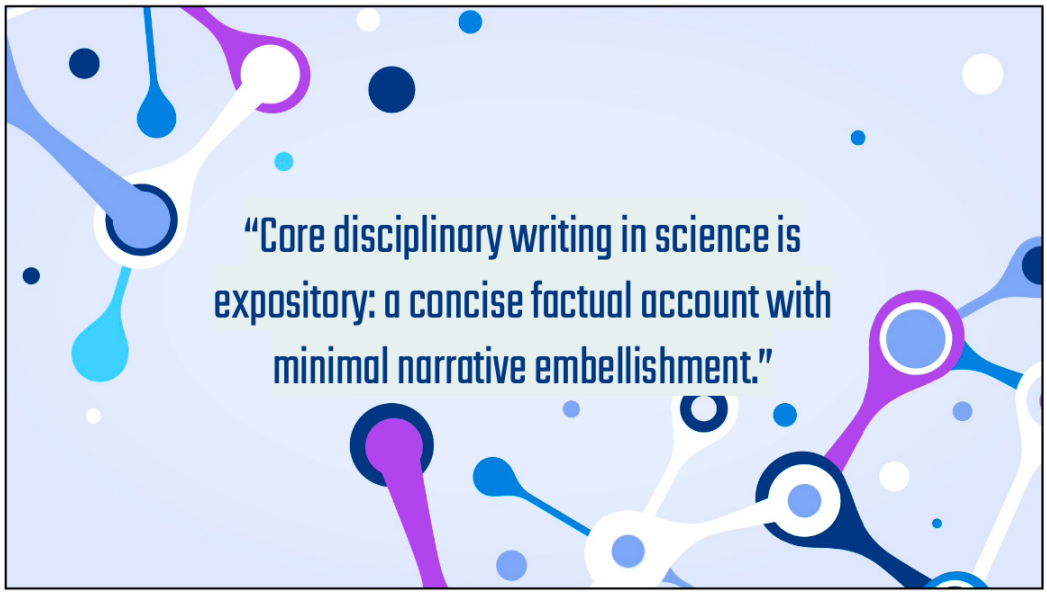

Specific Reading Strategies
Choose a research paper to read based on title
Read the abstract and find it interesting and relevant
Go to the end of the paper to judge how strong the conclusions are


Specific Reading Strategies
Flip through the figures (tables, graphs, illustrations, photos) in the paper to get a sense of the data presented
Identify a key figure, read the legend, and make judgments on power and accuracy of the data
Return to the abstract and make some notes


Specific Reading Strategies
Read the introduction, check a reference at end of paper, and retrieve that related paper
If experimental methods are unfamiliar or questionable, read in detail and check related references
They pay special attention and take notes on what the authors should do next, are saying they will do, and likely will actually do

Appendix B

Writing Like a Scientist Notes



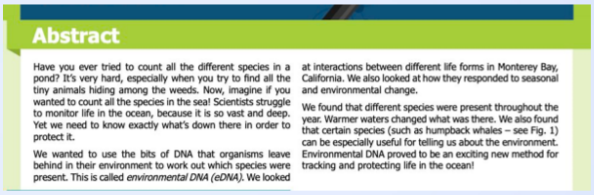
Structure of A Scientific Journal Article

Title

The title informs the reader of the specific research result that is being reported. This is typically a **one-sentence statement** of the main finding. Readers use the title as a first-order filter for deciding whether to read the report.

Abstract

The abstract is a brief summary—typically between 50 and 400 words—of the question or problem, the method used, the data obtained, and the conclusions drawn.



Abstract

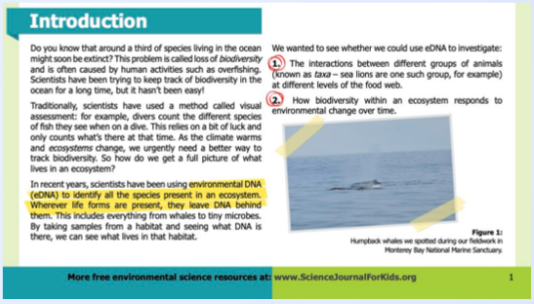
Have you ever tried to count all the different species in a pond? It's very hard, especially when you try to find all the tiny animals hiding among the weeds. Now, imagine if you wanted to count all the species in the sea! Scientists struggle to monitor life in the ocean, because it is so vast and deep. Yet we need to know exactly what's down there in order to protect it.

We wanted to use the bits of DNA that organisms leave behind in their environment to work out which species were present. This is called *environmental DNA (eDNA)*. We looked at interactions between different life forms in Monterey Bay, California. We also looked at how they responded to seasonal and environmental change.

We found that different species were present throughout the year. Warmer waters changed what was there. We also found that certain species (such as humpback whales – see Fig. 1) can be especially useful for telling us about the environment. Environmental DNA proved to be an exciting new method for tracking and protecting life in the ocean!

Introduction

The introduction explains what questions and problems the experiments were intended to address and **provides background** for the broader context and importance of the experiments.



Introduction

Do you know that around a third of species living in the ocean might soon be extinct? This problem is called loss of *biodiversity* and is often caused by human activities such as overfishing. Scientists have been trying to keep track of biodiversity in the ocean for a long time, but it hasn't been easy!

Traditionally, scientists have used a method called visual assessment: for example, divers count the different species of fish they see when on a dive. This relies on a bit of luck and only counts what's there at that time. As the climate warms and *ecosystems* change, we urgently need a better way to track biodiversity. So how do we get a full picture of what lives in an ecosystem?

In recent years, scientists have been using environmental DNA (eDNA) to identify all the species present in an ecosystem. Wherever life forms are present, they leave DNA behind them. This includes everything from whales to tiny microbes. By taking samples from a habitat and seeing what DNA is there, we can see what lives in that habitat.

We wanted to see whether we could use eDNA to investigate:

1. The interactions between different groups of animals (known as *taxa* – sea lions are one such group, for example) at different levels of the food web.
2. How biodiversity within an ecosystem responds to environmental change over time.

Figure 1: Humpback whales we spotted during our fieldwork in Monterey Bay National Marine Sanctuary.

More free environmental science resources at: www.ScienceJournalForKids.org 1

Methods

The methods are the experimental approach is described in careful but **succinct** detail. This section is intended to make it possible for a reader to understand exactly how experiments were done and to even **replicate** the experiments independently for themselves.

SCIENCE JOURNAL TEENS

JUNE 2020
HOW CAN WE TRACK LIFE IN THE OCEAN?

Methods

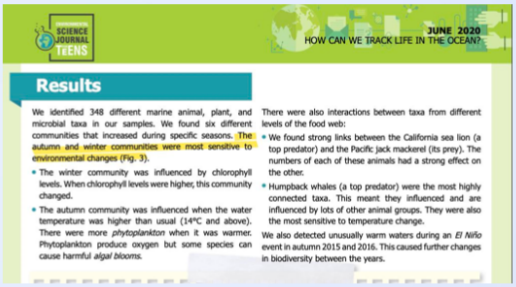
We collected seawater samples from the Monterey Bay National Marine Sanctuary in California. We did this eight times between April 2015 and December 2016. We lowered a *rosette* with water collection bottles (Fig. 4) from our boat at a depth of between zero and one meter. We then filtered the water and flash froze the filters in liquid nitrogen to keep them at a chilly -80°C! At the same time, we recorded information such as water temperature and the amount of *chlorophyll*.

We then took our samples back to the lab and extracted the DNA. Each species has its own unique DNA "barcode". We used this to work out which species were present in the water. Each barcode contains a *conserved region* – this tells us broadly what it is, for example, a mammal or bacteria. There's also a *variable region* which we use to identify the species (Fig. 2).

We then grouped taxa into communities that had similar changes in numbers over time. This could be because of a predator-prey interaction. For example, when the numbers of copepods (a small type of crustacean) increased in winter, so did the numbers of Pacific jack mackerel (which eat them!). We used this to look at how biodiversity changed over the seasons and across different levels of the food web known as *trophic levels*.

Results

The results section presents the **data** that were obtained from experiments and typically contains data tables, graphs, illustrations and images. Accompanying text gives a fuller **description** of the data.



SCIENCE JOURNAL TEENS

JUNE 2020
HOW CAN WE TRACK LIFE IN THE OCEAN?

Results

We identified 348 different marine animal, plant, and microbial taxa in our samples. We found six different communities that increased during specific seasons. The autumn and winter communities were most sensitive to environmental changes (Fig. 3).

- The winter community was influenced by chlorophyll levels. When chlorophyll levels were higher, this community changed.
- The autumn community was influenced when the water temperature was higher than usual (14°C and above). There were more *phytoplankton* when it was warmer. Phytoplankton produce oxygen but some species can cause harmful *algal blooms*.

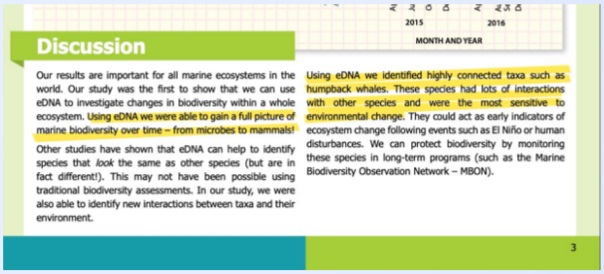
There were also interactions between taxa from different levels of the food web:

- We found strong links between the California sea lion (a top predator) and the Pacific jack mackerel (its prey). The numbers of each of these animals had a strong effect on the other.
- Humpback whales (a top predator) were the most highly connected taxa. This meant they influenced and are influenced by lots of other animal groups. They were also the most sensitive to temperature change.

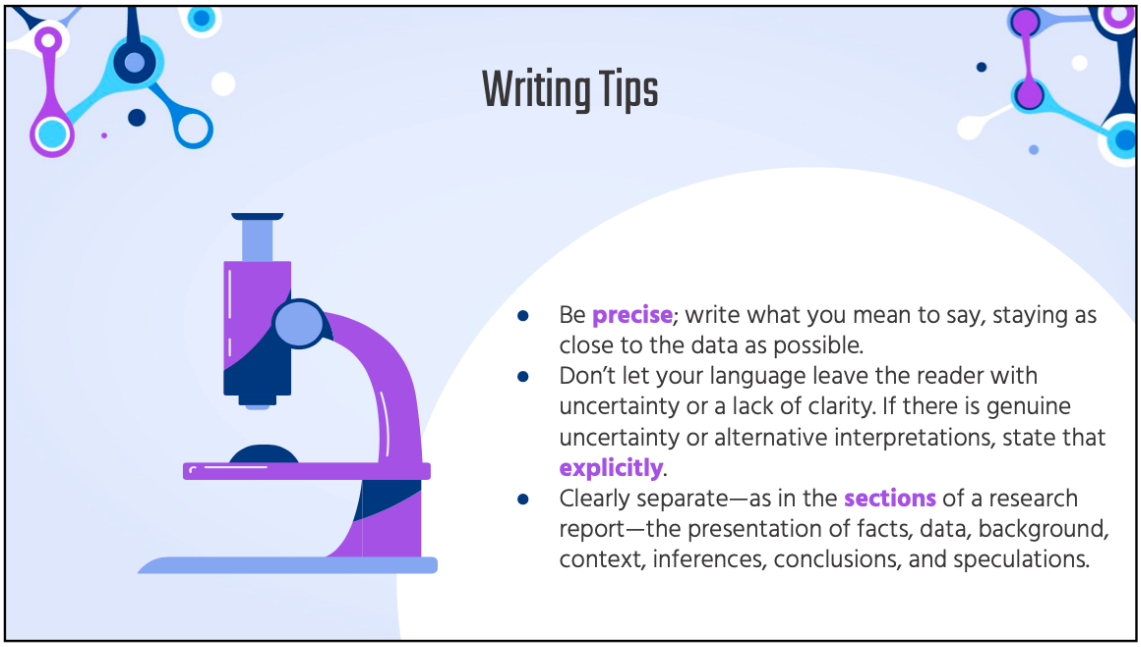
We also detected unusually warm waters during an *El Niño* event in autumn 2015 and 2016. This caused further changes in biodiversity between the years.

Discussion

The discussion includes more conclusive statements from the researchers' interpretation of the **meaning** of the data. This section is likely to include statements about **future** experiments and research directions.

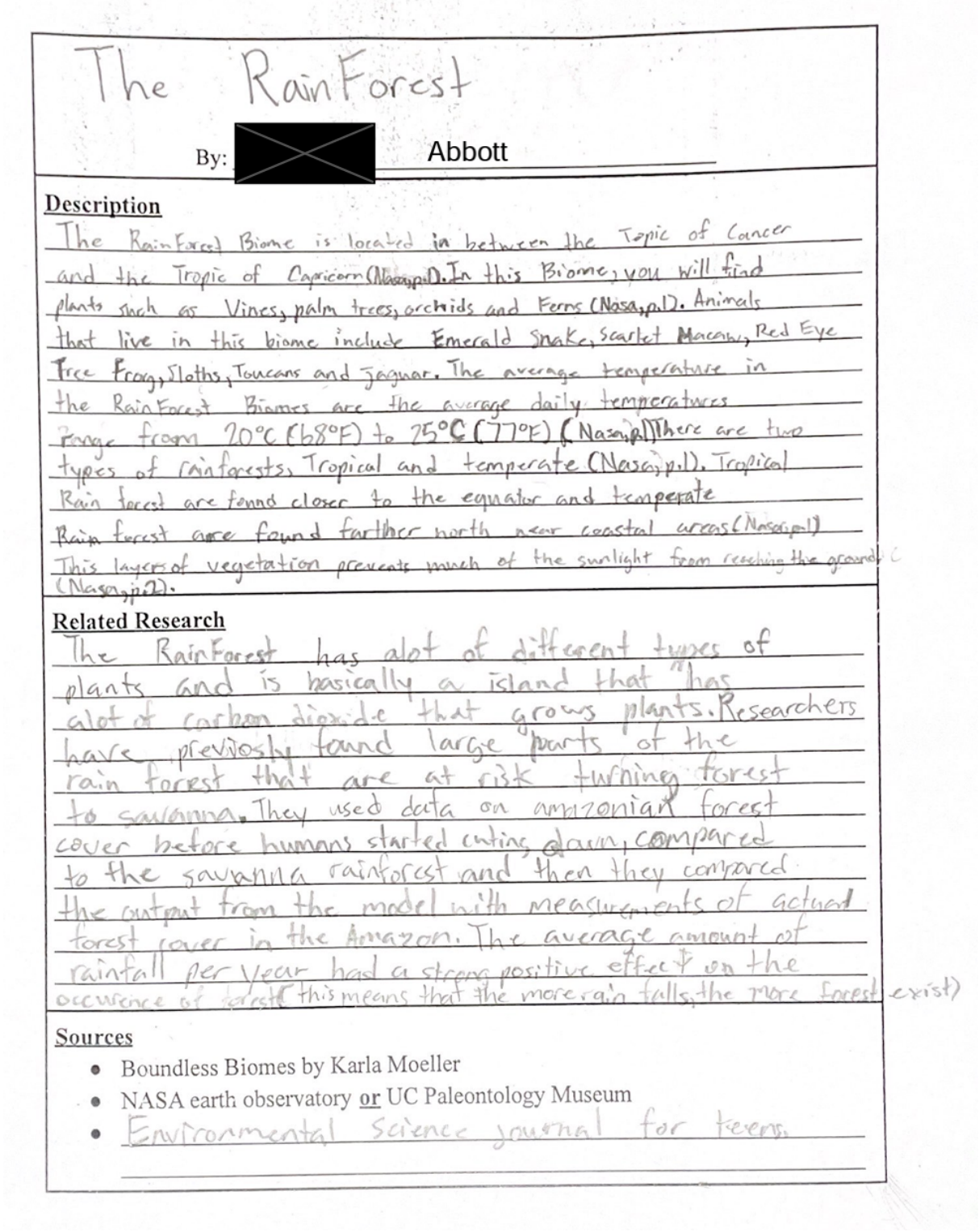


Writing Tips


Writing Tips
Be precise; write what you mean to say, staying as close to the data as possible.
Don't let your language leave the reader with uncertainty or a lack of clarity. If there is genuine uncertainty or alternative interpretations, state that explicitly.
Clearly separate—as in the sections of a research report—the presentation of facts, data, background, context, inferences, conclusions, and speculations.

Appendix C

Sample of Student Work



The RainForest

By: [redacted] Abbott

Description

The RainForest Biome is located in between the Topic of Cancer and the Tropic of Capricorn (Nasa,p.1). In this Biome, you will find plants such as Vines, palm trees, orchids and Ferns (Nasa,p.1). Animals that live in this biome include Emerald Snake, Scarlet Macaws, Red Eye Tree Frogs, Sloths, Toucans and Jaguar. The average temperature in the RainForest Biomes are the average daily temperatures range from 20°C (68°F) to 25°C (77°F) (Nasa,p.1) There are two types of rainforests, Tropical and temperate (Nasa,p.1). Tropical Rain forest are found closer to the equator and temperate Rain forest are found farther north near coastal areas (Nasa,p.1) This layers of vegetation prevents much of the sunlight from reaching the ground (Nasa,p.2).

Related Research

The RainForest has alot of different types of plants and is basically a island that has alot of carbon dioxide that grows plants. Researchers have previosly found large parts of the rain forest that are at risk turning forest to savanna. They used data on amazonian forest cover before humans started cuting down, compared to the savanna rainforest and then they compared the output from the model with measurements of actual forest cover in the Amazon. The average amount of rainfall per year had a strong positive effect on the occurence of forest this means that the more rain falls, the more forest exist)

Sources

- Boundless Biomes by Karla Moeller
- NASA earth observatory **or** UC Paleontology Museum
- Environmental Science journal for teens.

Appendix D

Codebook

Code	Level	Definition	Example	Color Code
Compartmentalization of Reading and Writing to ELAR Classes	2	Some students believe reading and writing should only happen in their ELAR classes.	"Kellsie made the comment 'I thought this was science not English.' Barnett made the comment 'This is science not reading.'"	Red Highlight
Not Seeing the Difference Between Disciplines	1	Some students did not see the difference between reading and writing across disciplines.	"Rob said that reading in English class was the same as reading in science class."	Dark Blue Underline
Seeing The Literary Differences Across Disciplines Over Time	1	While some students were not able to see the differences in literacy across disciplines, others were able to start to see the differences throughout the course of the study.	"Eventually, Bailey pointed out that the quote was saying scientists read differently."	Tan Highlight
Positive Student Perceptions of Strategies	2	Some students noticed the importance of reading and writing outside of ELAR class.	"I think reading and writing is necessary in a science class to learn or do something step by step."	Pink Underline
Identifying How Reading and Writing are Beneficial for Scientists	1	Students were able to identify how reading and writing were beneficial to scientists, despite compartmentalizing reading and writing to their ELAR classes.	"To keep a straight database like say that you're like on uh trial and error during a thing you could go back and look at what you did wrong and try to fix it."	Light Green Highlight

Understanding The Sections of a Research Paper	1	Students were able to explain what was included in each section of a research paper.	"When having these discussions and asking them these questions, all four of them were able to accurately identify and describe each section of a research journal article."	Orange Underline
Hands-On Learning	1	Students want hands-on learning when working on disciplinary literacy.	"And then like the papers we have to do for the labs like 'cause we are already hands on and then we can answer questions."	Purple Underline
Negative Student Perceptions of Strategies	2	Some students in general did not enjoy the reading and writing assignments.	"This is NOT English class."	Dark Yellow Underline
Wanting Simplicity in Disciplinary Literacy in Science	1	Students want the work to be simple and easy to understand.	"Barnett, in reference to a dichotomous key, said 'why not just whale?' wondering why we could not use the common name on a dichotomous key instead of the Latin, taxonomy name."	Orange Highlight
"I Don't Know"	1	This was a common answer for students to resort to quickly.	"I don't know how to answer this."	Dark Yellow Highlight
Apathy Toward Reading and Writing	1	Some students did not want to do the work and did not care to do the work.	"I don't like reading because of how long it can sometimes be."	Brown Highlight
"This Is Boring"	1	Some students thought the reading and writing we did in class was boring.	"I don't like reading because it's boring"	Purple Highlight

"I Don't Like It"	1	Aspects of this project that students did not like.	"I dislike having to read for a long time or write for a long time."	Red Underline
Teachers' Positive Perceptions of Strategies	2	Reasons why teachers would teach disciplinary literacy in the future	"I kind of think you had to since the whole point was to learn how to read and write like a scientist…I thought that part was really beneficial."	Dark Green Underline
Not Focused on in Previous School Years	1	Teachers believed they had not focused on reading and writing at any point before this study.	"No, I assumed all children that have made it to the 7th grade are able to read."	Neon Yellow Highlight
Negative Teacher Perceptions About Student Literacy Abilities	2	Teachers' negative perceptions over how the students completed the work.	"They're not able to come up with original ideas anymore"	Dark Blue Highlight
Students Incapable	1	Students are not currently capable of reading or writing texts for certain periods of time.	"I can tell you the majority of children have the attention span of about three minutes and they're not capable of reading and writing for long periods of time anymore."	Pink Highlight
Own Words/Copy Paste	1	Students end up using copy and paste rather than synthesizing into their own words.	"They usually just wanna read something and they just wanna copy and paste it"	Dark Green Highlight
Teachers Come Up with Future Solutions	2	As a result of the study, teachers began to come up with solutions for teaching disciplinary literacy in future classes.	"Like this kind of these kind of things you just have to give them like a specific template to follow or otherwise they have	Black Underline

			no idea what to do…"	
Highly Structured Instruction	1	Disciplinary literacy activities should be highly structured.	"Most of it was done at home, that's what I mean by not as structured."	Brown Underline
Start Early and Build Over Time	1	Disciplinary literacy strategies should be taught from day one and built up over time.	"I think that should be part of the beginning of science class whenever you're learning about just science tools and science rules and how to act like a scientist and think like a scientist then you could integrate how to read and write like a scientist"	Light Blue Underline