THE EFFECT OF DELIBERATE INSTRUCTION OF SCIENCE DISCIPLINARY LITERACY STRATEGIES ON SCIENCE SELF-EFFICACY OF SCIENCE STUDENTS

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Abstract

This study evaluates the effect of disciplinary literacy instruction on student self-efficacy in high school biology. An action research project, this study employed a mixed-methods approach, integrating both quantitative and qualitative methodologies. The quantitative component included a self-efficacy assessment adapted from the *Metacognition, Self-Efficacy, and Learning Processes in Science* survey by Thomas et al. (2008), administered as a pre- and post-test to measure changes in students' self-efficacy in biology class. The qualitative component consisted of student reflective journals and focus group conversations, with insights from the researcher's reflective journal entries. These data provided insight into students' experiences with and opinions of various disciplinary literacy tools. Findings indicate that self-efficacy in biology increased following the implementation of disciplinary literacy instruction. These results suggest that explicitly teaching students how to approach scientific texts through a disciplinary literacy framework can enhance their confidence and engagement with science content. This study contributes to the growing body of research on literacy-based science instruction and its role in growing student self-efficacy.

Chapter 1: Introduction

When asked about science classes, students often report they are not good at science (Jones et al., 2021). When this is the attitude or belief at the onset of a course of study, students tend to fulfill this belief and do not thrive in the scientific disciplines. The opposite of this thought process is when a student believes they can succeed and sees themselves as successful scientists. From this alternate view, students tend to experience more success and achieve at a higher level in their science classes (McBride et al., 2020). This mindset aligns with self-efficacy theories and research (Bandura, 1977, 1989; Grabau & Ma, 2017; Jones et al., 2021; McBride et al., 2020; Tsai et al., 2011).

Self-efficacy is one's belief in one's ability to perform a specific task, and it determines how people feel, think, or motivate themselves and refers to their confidence to achieve the desired outcome (Bandura, 1989). Research on self-efficacy supports the link between possessing a positive self-outlook and achieving success in the classroom (Grabau & Ma, 2017; Jones et al., 2021; McBride et al., 2020; Tsai et al., 2011). Additionally, students who believe in their learning efficacy, or their ability to acquire new skills or knowledge, develop and maintain the effort and thought needed for learning (Tsai et al., 2011). Helping students develop efficacy toward learning and a belief in their ability to perform at a high level in academic tasks can yield academic success for the student (Bandura, 1977, 1989; Grabau & Ma, 2017; Jones et al., 2021; McBride et al., 2020; Tsai et al., 2011). However, there are many ways students are deterred from believing that they may thrive in the field of science. Among these roadblocks are the language and literature of science itself (Cervetti & Pearson, 2012; Chatzikyriakidou & McCartney, 2022; Koomen et al., 2016; Lemke, 1989; Unsworth, 2006).

Research supports the notion that using discipline-specific literacy (e.g., primary

scientific literature) promotes critical thinking, experimental design ability, and epistemological maturation (Chatzikyriakidou & McCartney, 2022; Yore et al., 2007). While the use of primary scientific literature is an excellent way to promote and develop scientific thinking and increase efficacy in students, samples can be text-dense and challenging to read without instruction in the use of disciplinary literacy tools (Cervetti & Pearson, 2012; Shanahan & Shanahan, 2008, 2012). This is often due to the complexity of scientific text, which can prevent students from fully engaging with the literature presented (Lemke, 1989). This difficulty could be addressed through deliberate instruction of discipline-specific literacy tools that allow students to navigate and apply content information in scientific literature.

Disciplinary literacy is an approach to content-specific reading education that focuses on teaching students the strategies and tools designed for each discipline (Cervetti, 2021; Yore et al., 2007). This approach is demonstrated in science by emphasizing support for students while they learn to read and write like professional scientists. The disciplinary literacy approach engages students in ways that mirror the practice of science versus simply reading about science. For example, students read primary literature from scientists in the field through journal publications and connect the content learned from class to what they are reading. Using disciplinary tools when reading primary scientific literature will help students improve comprehension and apply the information they are reading to the discipline-specific content they learn in class (Cervetti & Pearson, 2012).

There are several best practices used in general literacy that can be employed to improve students' disciplinary literacy skills. Examples of these strategies include highlighting and annotating, using graphic organizers, creating concept maps, and using primary literature as anchor texts. By delivering instruction with deliberate explanations on how to use these tools

with scientific literature, students may be better equipped to extract and apply content information from text. Students can better engage with scientific literature by improving disciplinary literacy skills. The shift from simply reading and writing about science to reading and writing as a scientist can change their self-image from science students to actual scientists. Students' ability to see themselves as scientists has been linked to improved self-efficacy in science (Jones et al., 2021).

Rationale/Problem Statement

That students struggle with the language of science is well-researched (Cervetti, 2021; Gee, 2004; Lemke, 1998a; Tovani, 2004; Unsworth et al., 2022; Wright & Gotwalls, 2017; Yore et al., 2007). This is generally because the academic nature of scientific language has long been deemed challenging to process and understand yet critical for success in science classes (Cervetti, 2021; Gee, 2004; Kelly et al., 2023; Kuhn et al., 2017; Lemke, 1989, 1998a; Unsworth, 2006; Unsworth et al., 2022; Wright & Gotwalls, 2017; Yore et al., 2004). Whether it is the difficulty of the content, the density of the writing, vocabulary, or the way that text interacts with drawings, figures, charts, and models, students find the language of science difficult (Lemke, 1998a, 1998b; Unsworth, 2006; Yore et al., 2007). Engaging with reading in science often presents blocks that prevent students from fully participating in learning science. Thus, students who struggle with the language and need help navigating the complexities of primary literature may find it challenging to see themselves succeed in science.

Primary scientific literature is an example of the genre of writing students may engage with to provide relevance and context for content-specific information. Primary scientific literature includes samples of research from scientists, articles published in reputable research journals, or final reports on findings from empirical research. Emerging research has shown that

students who work with primary scientific literature can improve their science self-efficacy (Chatzikyriakidou & McCartney, 2022). Providing students with tools to improve their abilities to read, process, and understand this type of writing can yield success in delivering a relevant application of content and improve their self-efficacy.

The use of academic and scientific discourse generally requires students to enter a language community completely separate from their family and friends (Brown et al., 2005; Brown & Spang, 2007; Gee, 2004; Yore, 2008). Many students do not use academic vocabulary at home or in discourse with their friends, so when faced with it on a printed page, it can be intimidating and affect their science self-efficacy. Improving understanding through practice outside of the classroom is challenging because conversations with families and peers typically involve using a more casual vernacular (Gee, 2004).

The struggle associated with engaging with science discourse is especially true for Emerging Bilingual students (EBs) who generally only utilize English in school and have fewer opportunities for practice. For this reason, EBs struggle with academic language (Martinez et al., 2014). EB students generally take as many as seven years to attain full acquisition of academic language (Pearce et al., 2020). Thus, these students can spend their entire four-year high school career studying academic language and graduate without fully grasping the language used in classrooms. For these students to fully engage in the practice of reading and writing like scientists, it is especially important that they receive instruction to use disciplinary literacy tools that help them navigate scientific text.

Research Questions

This study examines the impact of classroom instruction of disciplinary literacy on student self-efficacy in science. Two research questions guide this research. The first question is:

What are the effects of instructing high school students to use disciplinary literacy tools to read scientific literature on science self-efficacy? This question guides inquiry about specific self-efficacy outcomes of disciplinary literacy instruction. The second question is: How does the deliberate instruction of disciplinary literacy tools affect student self-efficacy in biology? Answers to the second question will inform the action research cycle and show how specific disciplinary literacy tools impact student science self-efficacy.

Significance of Study

While there is an abundance of research on self-efficacy, literacy, and strategies independent of one another, there is a gap in the literature addressing the effect of teaching students how to read and interpret primary scientific literature on student efficacy in science. When students can experience mastery of a task, they have an increase in efficacy (McBride, 2020; Scott, 1996). Additional research has shown that students with higher efficacy are more likely to succeed in science classes (Grabau & Ma, 2017; Jones et al., 2021; McBride et al., 2020; Tsai et al., 2011). By providing students with a path to mastery through deliberate instruction of disciplinary literacy strategies specific to science, they will gain skills that allow them to fully understand and apply learning from the literature of science.

Terms

This research uses terms that may have specific context-bound meanings. Therefore, the following terms are defined as used in this research.

Disciplinary literacy- The specifics of a discipline's reading, writing, and communicating. It focuses on the ways of thinking, the skills, and the tools that are used by experts in disciplines.

Content area literacy- A literacy education approach that applies generic methods and tools to all areas and disciplines.

Self-efficacy- A person's belief in their ability to succeed in a particular situation.

Deliberate instruction- A thoughtful, purposeful, and metacognitive approach to teaching to provide students with a meaningful and enriching learning experience.

Chapter 2: Literature Review

This literature review lays out existing research on self-efficacy, scientific language, disciplinary literacy, and best practices for instruction. Each main area of research includes sub-sections.

Self-Efficacy

Self-efficacy is defined as the way one perceives one's ability to achieve a goal or perform a task (Bandura, 1989). Self-efficacy determines how people feel, think, or motivate themselves and refers to their confidence to achieve the desired outcome. It can be a factor in a student's ability to achieve and contribute to the acquisition of knowledge and the development of skills. Students who believe in their learning efficacy, or their ability to acquire new skills or knowledge, develop and maintain the effort and thought needed for learning (Tsai et al., 2011). Self-efficacy is a powerful human emotion that holds significant power over the mind and the ability to succeed at high levels (Scott, 1996).

Sources of Self-Efficacy

Research by Bandura (1977) defined four sources of self-efficacy: performance accomplishments, vicarious experience, verbal persuasion, and emotional arousal. The two most powerful are performance accomplishments and vicarious experiences.

Performance accomplishments include participant modeling, performance desensitization, performance exposure, and self-instructed performance. Participant modeling in efficacy occurs when individuals are provided with a model of how to apply a skill when dealing with a stressful situation, and the participant is given opportunities to translate the behavioral concept to action and given feedback for improvement in the implementation. Successful performance of a task is the primary driver of success in participant modeling (Bandura, 1977).

Performance desensitization pairs a stress-inducing event with an activity that will reduce stress, while performance exposure occurs when the participant experiences success while performing a task. The process of self-instructed performance happens when a participant is able to perform a series of self-directed mastery experiences (Bandura, 1977).

Each of the four elements of performance accomplishments was shown to increase efficacy. Researchers found that performance-based treatments promoted behavioral accomplishments, such as improved self-efficacy, motivation to do a difficult task, and decreased fear of failure (McBride et al., 2020). With success, expectations are increased, and with failures, they are lowered (Bandura, 1977; McBride et al., 2020).

Vicarious experiences describe the building of efficacy by seeing others succeed, such as in the instructional practice of modeling. They happen when participants see another accomplish challenging tasks. Vicarious experiences were not as influential in changing efficacy, but they did yield improvement. Researchers noted that in isolation, modeling did not yield as strong of a benefit to efficacy as an individual experiencing success in a threatening activity as they would experience in a performance task. Therefore, vicarious experiences are important for the improvement of self-efficacy, but mastery experiences provide a more improved response (Bandura, 1977).

Self-Efficacy and Motivation

There is a definite connection between self-efficacy and motivation. Research by Cavas (2011) found that Turkish students who were highly motivated to succeed did show improvement in their achievement scores. There was a wide range of variables that contributed to student motivation, including science learning value, active learning strategies, achievement goals, performance goals, and self-efficacy. When statistics were calculated for the participants

in their study, they found that there was a positive relationship between efficacy and motivation. The level of student motivation was found to be connected to student achievement (Cavas, 2011).

A study by Scott (1996), outlined goals and practices, within the field of literacy, that impact student efficacy. She found that when students perceived they could achieve at a high level, they were more motivated to persevere in difficult situations and try harder. When this motivated push to succeed was met with positive outcomes, their efficacy grew, and they continued to achieve at high levels (Scott, 1996).

A study with college students examined the connection between motivation and reading Primary Scientific Literature (PSL). Chatzikyriakidou & McCartney (2022) found that when presented with the literature that is typical in science, students who received no guidance scored significantly lower in achievement and motivation than those students who did readings in a guided setting. Results also reinforced a common pedagogical best practice of guidance, modeling, and working within a group when approaching a novel task. Students assigned readings of PSL in study groups with the supervision and guidance of a teaching assistant scored the highest for achievement and motivation for the task (Chatzikyriakidou & McCartney, 2022).

Self-Efficacy and Achievement

A large body of evidence exists to support the concept that high self-efficacy will yield higher achievement in science (Grabau & Ma, 2017; Jones et al., 2021; McBride et al., 2020; Scott, 1996; Tsai et al., 2011). Tsai et al. (2011) examined the relationship between science knowledge and how it is acquired, science self-efficacy, and achievement. They found that the way students viewed knowledge in science changed their efficacy perception, which also changed their level of achievement. This study found that students who viewed science epistome

as fixed and held a concept of learning science as memorization and recall had an incredibly low science efficacy and tended not to thrive. Whereas students who viewed science epistome as knowledge in science is fluid and changes in the light of new evidence and whose conceptions of science learning were that of discovery and inquiry had a higher science efficacy and higher achievement scores (Tsai et al., 2011).

Other studies have evaluated the link between efficacy and scientific achievement. A study with elementary students tapped into young students' desire to play dress-up and wear costumes and the societal association of scientists wearing white lab coats (Jones et al., 2021). Through a pre- and post-interview review, they found that student efficacy for science improved when they dressed like scientists. Student responses indicated they felt smarter wearing the lab coat and expressed feelings that they could do science better if they were wearing them. Because the students saw themselves as real scientists, their self-efficacy and performance improved (Jones et al., 2021).

Students in science classes struggle to succeed and report having low self-efficacy (McBride et al., 2019). In this research, non-science major students were studied to find ways to improve their self-efficacy in science class. The anticipated outcomes were to examine the development of students' science self-efficacy beliefs and sense of connection to science and to understand the instructional and individual factors that support these beliefs. The expected result was that science self-efficacy would show a positive association with students' connection to science and a negative association with science anxiety. They examined the study participants' academic and demographic backgrounds to include prior science academic experiences and students who are typically unrepresented in STEM fields, such as students of color and women. They predicted that those with favorable previous experiences would demonstrate higher self-

efficacy in science, and those from underrepresented groups would report lower self-efficacy (McBride et al., 2019).

McBride et al. (2019) used Bandura's (1977) research to establish codes for sources that contributed to student self-efficacy in science. These sources included mastery experience, vicarious experience, social persuasion, and emotional/physical states as they relate to instructional strategies and classroom experiences. The most frequently coded source of efficacy was mastery experiences. Student commentary on mastery experiences included, but was not limited to, effectively demonstrating a skill, successfully applying a scientific principle to solve or understand a "real life" issue, getting a good grade, or simply realizing that they could explain a scientific concept or approach (McBride et al., 2019).

Language of Science

"Language is an integral part of science- it is a means to doing science and to constructing science claims and an end by virtue of its use to communicate the inquiries, procedures, and science understandings to other people…" (Yore et al., 2004, p. 338). The core of communication in any discipline is language. In science, there are many means of communicating, and one form does not hold hierarchy over the others as they are all essential to convey meaning. It is important to attend to all means of communication in science to be able to derive meaning from scientific text. However, scientific language is hard to process and understand and presents challenges to those who are unfamiliar with the discourse and unique patterns within scientific texts (Gee, 2004; Kuhn et al., 2017; Lemke, 1989, 1998a, 1998b; Unsworth et al., 2022; Unsworth, 2006; Wright & Gotwalls, 2017). Among these challenges are the multiple modes of conveying meaning and the complexity of text features. Lack of access to and understanding of the previously mentioned modes can prevent students from being able to

participate fully (Gee, 2004).

Scientific Discourse

Entry into the discourse of science can be daunting for students, especially if they've had limited experience communicating in this way. By teachers engaging in conversation utilizing science vocabulary and text structure students will find it easier to engage in the reading and writing of science. The opportunity to engage in conversation about science with specific scaffolds provides students with an entry point to the discourse community (Wright & Gotwalls, 2017).

Lemke (1989) described the idea of making text talk and giving the textual facets of science a voice. This research examined the ways in which scientific text becomes an interactive and demonstrative way of understanding the concepts of science. By learning to describe and follow the thematic patterns of science while using their own words, students demonstrated comprehension of a scientific concept. In contrast, when students provided rote memory responses, the same way they are found in text, it was a demonstration of compliance and lacked the metacognition needed to demonstrate a full understanding of the content being reviewed. In order not to simply copy the model of discourse found in text or given by teachers, students needed to process the information and be able to attach their own vocabulary to describe what occurred. Providing instruction on thematic patterns for answering helps them to do this better (Lemke, 1989).

The ability to speak and engage in scientific conversation like a scientist has shown to be an important component of improving content understanding but Roth (1994) found that a single mode of discourse is not enough to fully engage students in conversations about science. In this study, researchers observed students designing and improving a pulley system. Oral discussion

with a singular note-sharing point, overhead transparencies, did not allow all students to participate and engage in the knowledge-making processes. When students were given chalkboards to illustrate their ideas while talking about them, conversations became more inclusive at a higher level of scientific discourse. The added mode of communicating scientific thinking improved the entire experience for all students as they now had an access point into the community discourse (Roth, 1994).

In order to bring students into the science discourse community, teachers blend student vernacular with scientific discourse to explain content information. This hybrid form of communication is referred to by researchers as double talk. Researchers thought if students were allowed to engage in the vernacular of the science community, they would be more engaged in science practices. To test this, researchers developed a four-phase approach to instruction that prepared students for the discourse of science by mixing science vernacular with the everyday language of students to ease students' transition to using academic language in the classroom. These phases include preassessment instruction, content construction, the introduction of explicit discourse, and scaffolding opportunities for discourse. This approach was successful in that students could gain a conceptual understanding of the scientific content while engaging in the academic language of science on an academic level (Brown & Spang, 2007).

The Literature of Science

Science literature is unique in its organization, contents, and use of text features such as graphs, diagrams, models, charts, and footnotes (Shanahan & Shanahan, 2008). Verbal discourse is linear, and narrative text found in English literature classrooms is linear, with a start, middle, and end. Scientific text is generally not intended to be only read from beginning to end in the same fashion as other student reading experiences. Usually, scientific text is meant to be read in

a sequence that, at times, requires looking at a graph at the top of the page or while reading a paragraph attend to a footnote in midway through that provides clarification to a point in data analysis. Many other aspects of scientific text contribute to the story being told, such as who supported the research, the type of data collected, the research location, and even the researchers' background (Lemke, 1998a). Attention to these many text features and how to utilize them are all habits of expert readers and vary depending on the thematic pattern set by the purpose of the reading (Shanahan & Shanahan, 2012).

Lemke (1998b) found that text features such as graphs, diagrams, and models were not merely supplementing the natural language within each article but were, in fact, part of the language and necessary for understanding the material being reported. He found that there were more figures, diagrams, and graphics in the four issues of scientific journals than one would find in popular text. These graphics were integral to understanding the material being reported. The relationship between the text features in scientific writing bears a stark contrast to illustrations in more narrative works that students read in the English language arts and reading (ELAR) classes.

Within scientific text, there exist specialized text features and mathematical symbols that cannot be shared through spoken language. The unique nature of scientific language makes it necessary that instruction of scientific literacy is not tied to memorization but rather to the phenomena or lived experiences of the learner (Yore et al., 2007). In another study, researchers pointed out the necessity of providing students support for learning to talk, write, and read science as they are all interconnected in the practice of doing science. The researchers stated, “Science learning and discourse in classrooms connects talk, informal personal experiences, everyday terms, and concrete experiences; knowledge constructions and established knowledge claims become stored in print and digital sources.” (Yore & Treagust, 2006 p. 296). This

research underlines the need for students to be proficient in reading primary scientific writing and comfortable communicating in the scientific discourse community (Gee, 2004; Yore & Treagust, 2006).

Challenges for Emerging Bilingual Students

The challenges presented by academic language are even greater for students who are learning English. Pearce et al. (2020) noted that for students learning English, it takes approximately two years to learn social English and five to seven years to acquire the academic language used in the educational system in the United States. This means that students are not only navigating content but also learning the language of schooling. This makes the challenge of being comfortable with content even more difficult as they also struggle with language. In this research, investigators engaged students in a hands-on model of ecosystem structure. Researchers looked to see how engaging in an interactive model would affect emerging bilingual students' content and language development. They found that various aspects of the model yielded different effects, but overall, students who were actively engaged in the activity tied to content demonstrated a greater understanding of the content vocabulary (Pearce et al., 2020).

In a piece examining culture, language, and the relationship of both with science, Yore (2008) discussed the importance of attending to students' home culture, language, and beliefs when teaching science. The article addresses the issue that nearly every student in a science classroom is acquiring a new language and entering a new discourse community. This point is even more true for students with a home language other than English and a cultural background not in line with Western Society (Yore, 2008). It is important to attend to a student's home language and culture and use this as an anchoring point to introduce them to the community of scientific discourse (Gee, 2004). One way this has been done in practice included utilizing

methods developed by Brown & Spang (2007) in which teachers engaged in double talk with students, incorporating student casual language and science vernacular as a parenthetical statement. Failure to address student backgrounds, both culturally and linguistically, can lead to students feeling disenfranchised with learning science and eliminates huge opportunities to engage prior experiences and knowledge they bring to the table (Yore, 2008).

Kelly et al. (2023) also addressed the difficulty students from historically underrepresented groups, including EBs, have when entering the scientific discourse community. Their research and discussion on the focus of science literacy practices without attention to the multi-modal nature of science discourse highlighted key points for improving literacy for all students in the future. One aspect of this research was the attention given to students learning English while simultaneously learning the complex language of science. Many students who are taking mainstream coursework fall into this category. They benefited from support and extra efforts from teachers who created a classroom culture of inclusion. Academic science is generally based on Western thinking and is a field that is dominated by white males. The discourse and writing have aspects of structure, vocabulary, and word use that make it into its own linguistic community. Entering this new community primarily based on Western white male ideals, beliefs, and interpretations can present additional difficulties for relevance and understanding for those who do not fit that demographic and have other ways of knowing that are rooted in Indigenous knowledge systems, cultural ecological practices or community-based understandings of the natural world (Kelly et al., 2023).

Connection Of Literacy and Self-Efficacy

Scott (1996) researched connections between literacy learning and self-efficacy. She found that students' motivation was impacted by their self-perceptions. Positive experiences with

reading led to students having a positive self-perception of their reading ability, and the end results are students finding joy in reading. If students did not have positive experiences, they tended to avoid reading because they feared they were going to fail anyway (Scott, 1996). These experiences impacted students' self-efficacies. To maximize classroom time and level instructional strategies, researchers found that structuring goals to maximize student motivation was key (Scott, 1996). When given learning goals centered on processes, students had an increase in self-efficacy. Conversely, when given performance goals that focus on outcomes, students who do not meet standards or perform below their peers tend to develop negative self-efficacy (Bandura, 1977; McBride et al., 2020; Scott, 1996).

Shanahan & Shanahan (2012) addressed the unique features of disciplinary discourse as a factor in changing the approach to teaching content area reading in secondary classrooms. When examining the differences between content literacy and disciplinary literacy, researchers noted that the use of language, symbolic artifacts, evaluation standards of quality and precision, appropriate vocabulary, and grammatical choices varied greatly between disciplines (Shanahan & Shanahan, 2012). One such example in the field of science was the use of nominalization of words. This means that words can fluidly move from noun to verb depending on the context. For example, evaporation is a noun that describes the process of liquids becoming gases but evaporate is a verb that describes the same process (Shanahan & Shanahan, 2012). The need for students to interact, discuss, and practice with the multiple modes of expression in scientific discourse has been noted by other researchers. Unsworth et al. (2022) discussed the need to develop a pedagogy to address these discourse needs in the classroom and gave students the opportunity to develop and gain access to these discourse communities. These nuances that are so unique to scientific discourse further contribute to the need to approach the teaching of

scientific discourse differently than one would in other disciplines (Shanahan & Shanahan, 2012; Unsworth et al., 2022).

Disciplinary Literacy

Disciplinary literacy is an approach to content-specific reading education that focuses on teaching students strategies and tools designed for each discipline (Madda et al., 2019). In contrast, content area literacy instruction focuses on applying generic reading tools and strategies from all disciplines to discipline-specific literature, such as textbooks (Cervetti, 2021). The initial focus of content literacy was to provide a more effective way for older students to engage with the literature from various disciplines and address the changing literacy needs as they progress through school. As students moved up in grade level, the text complexity in each discipline increased in difficulty and developed unique features depending on the nature of the discipline (Cervetti, 2021). This dichotomy was demonstrated in science by emphasizing support for students while they learn to read and write, like practicing scientists using authentic research texts for disciplinary literacy versus using generic vocabulary instruction methods as content area literacy. A disciplinary literacy approach engages students in the practice of science versus reading about science as they would with content literacy instruction (Cervetti & Pearson, 2012).

The field of disciplinary literacy addressed not only the shortcomings of strictly content-area reading but also the growing body of linguistic research that looks at how experts in various fields read and how language in that discipline is structured (Kelly et al., 2023; Roth, 1994; Unsworth et al., 2022; Yore, 2000, 2008; Yore et al., 2007). This is important to note because it recognized that the empirical roots of disciplinary literacy are not founded in the practice of teaching disciplinary literacy but in the linguistic fundamentals of the practice (Shanahan & Shanahan, 2012). In recent years, more instructional practices have been researched and

developed for use in classroom settings (Cervetti, 2021; Cervetti & Pearson, 2012; Fang & Coatoam, 2013; Goldman et al., 2016; Shanahan & Shanahan, 2008, 2012; Wolsey & Faust, 2013).

A disciplinary literacy approach to reading in a science classroom equips students with the ability to engage with the literature of the discipline in the same way practicing scientists would engage with it in their respective fields of research. The most important aspect of this immersion of reading and writing into the science classroom is that teachers need to incorporate reading and writing as part of the meaning-making process of science. Students need to learn that science is not simply a one-way model of reading and retaining facts but an interactive process of accessing prior knowledge and noting and highlighting aspects of the text on the page. It is a process of incorporating the reader's life experience, memories, and the text on the page. By presenting literacy instruction in this way, students can begin to approach reading and writing to learn in the same way as practicing scientists (Yore, 2000).

Disciplinary literacy has two ideas: first, immersing the learner in the literature that is unique to each discipline and second, that more informational texts should be incorporated into instruction (Wolsey & Faust, 2013). Incorporating informational texts into instruction allows students to engage with the discourse of specific disciplines and apply tools for navigating the literature. One way to incorporate disciplinary literacy into instruction is to utilize scientific text as a grounding point for studying novel phenomena (Wolsey & Faust, 2013).

Utilizing a disciplinary literacy approach improves students' informational text writing and deepens content understanding. Researchers examined the impact of disciplinary literacy instruction on first-grade students. They found that using a disciplinary literacy approach improved students' ability to recall scientific facts and use accurate definitions, as well as

improved their ability to write scientific informational text. Using disciplinary literacy embedded within content instruction allowed students to learn the science content while also learning about the unique text structures found in science and how to apply those tools in meaningful ways in their writing (Clark et al., 2021).

When scientists write, they do so for the benefit of other scientists, not for the general public. Much of their writing is in the form of a research report (Yore et al., 2004). This particular genre of writing is generally a fact-stating objective designed to report findings from research. Reports are written for publication in journals that the researchers themselves read and utilize. The discourse level is highly academic and follows the general scope of the Nature of Science. In this study (Yore et al., 2004), most study participants used a modernist view of the nature of science. A modernist believes that scientific knowledge is temporary and reflects existing evidence and current thinking in the field. The modernist view centers around the idea that claims are supported with evidence and the absence of evidence to refute them.

In the above-mentioned research, 19 university science faculty members were surveyed about their writing style and methods of writing (Yore et al., 2004). Most stated that the writing activities they engaged in were for a very specific audience. Most were used to record results, correspond with others in their fields, and prepare teaching material. Very few engaged in writing for the general population and expressed that the difficulty in doing so included that the lack of graphs and figures required them to describe findings rather than to refer to figures or graphs as you would typically find in academic journals (Yore et al., 2004). One respondent stated that when writing for a non-academic audience the guideline is, “the less expert the audience, the more general the writing” (Yore et al., 2004, p. 358).

The same group of university faculty stated they generally read peer-reviewed journals

they both subscribed to and published in, thus narrowing the scope of their literary experiences. When evaluating the discourse of writing, they noted that the quality of writing in preferred journals was influential in their choice of reading material and their own writing. As such, most of the writing of practicing scientists was written in the discourse of the academic science community and not at the level of most secondary school students (Yore et al., 2004).

Research reports from practicing scientists are not written at the reading level of most secondary students. Kooman et al. (2015) conducted professional development with 68 teachers and found that not only were teachers able to adapt these primary science articles for their students effectively, but the use of this Adaptive Primary Literature (APL) provided a gateway for students to experience the discourse of science while engaging in content learning. They also found that teachers who incorporated APL into their lessons deepened the meaning and richness of the sensemaking process of doing science for their students. Science textbooks generally eliminate the demonstration of argumentation that is fundamental in the communication of scientific findings. Using APL exposed students to this form of writing and discourse and allowed them to experience science as a practicing scientist (Kooman et al., 2015).

Best practices in disciplinary literacy instruction

Evidenced-based best practices for literacy instruction are defined as:

> "An instructional practice that has a record of success in improving reading achievement and is both trustworthy and valid. There is evidence that when this practice is used with a particular group of students, they can be expected to make a gain in reading achievement." (Malloy et al., 2019 p. 5).

These practices include the use of anchor texts, annotations and highlighting, admit strips, graphic organizers, double-entry diaries, and constructing concept maps.

Anchor Texts

Anchor texts are reading materials intended to seed student interest and investment in the content you are about to present. They are designed to set up the major concepts and should be followed up with additional textual information for support and supplementation (Risko & Walker-Dalhouse, 2019). Practicing scientists have utilized writing to clarify ideas and identify inconsistencies with their own claims (Yore et al., 2004). Survey respondents expressed the thought that the research report genre was the way to communicate claims, provide supporting and explanatory evidence, and offer argumentation and rhetoric to tie ideas to existing scientific understandings (Yore et al., 2004). This description of the genre generated by research scientists is similar to Claim-Evidence-Reasoning statements.

Anchor texts are of particular importance as they provided access to students who have traditionally been found to have limited exposure to authentic scientific literature. In a review of existing literature on multimodal literacy, Unsworth et al. (2022) drew attention to the fact that secondary students had fewer opportunities to interact with authentic texts and engaged in limited literacy activities in science classes. This limited exposure, makes the need for the opportunity to read, interpret and discuss authentic pieces of literature with opportunities for feedback from teachers exceptionally important. This was especially true for students from historically underrepresented groups or lower socio-economic groups (Unsworth et al., 2022).

Robb (2013) identifies anchor texts as a way to facilitate conversation with and among students in a structured way. Anchor texts were used to help students frame logical inferences and refine skills to be able to do this on their own. Use of anchor texts allowed students to gain entry to the conversation and read or write at their own instructional level. The discussions of ideas and sharing them with classmates helped students to learn from each other and observe

others move through the critical thinking processes. Follow-up assignments completed in class allowed students to read challenging text with support from the teacher and classmates (Robb, 2013).

Annotations and Highlighting

Being literate in a discipline means understanding both disciplinary content and disciplinary habits of mind. Students must not only know the science content but also the ways to navigate the reading and writing of science (Fang & Coatoam, 2013). When a scientist reads a research report they are not simply reading the information and recording it to memory. The scientist is highlighting important pieces of information, making notes on the margins and writing down connections to prior knowledge (Yore, 2000). Deliberate instruction on how annotate is necessary in order for students to successfully use strategies such as annotating they will need. Annotation is marking and writing on the text in a meaningful way. It is a practice that scholars have used for centuries, but students can find the task daunting when faced with scientific literature (Fisher & Frey, 2019).

Annotation and highlighting are tasks students may be familiar with from their English Language Arts and Reading (ELAR) courses and are practices that are recommended for Dual Language Learners (Fisher & Frey, 2019). Instruction in this practice should be explicit and meaningful and can include highlighting unfamiliar words and defining them, using context clues, underlining major points, and adding question marks to things that spark a question or wondering (Fisher & Frey, 2019).

Porter-O'Donnell (2004) observed the impact of deliberate annotation instruction with her reading students. She found that across the board, there were benefits to students understanding how and why to add annotations to reading passages. Results included improved

reading comprehension, improved writing skills, and a more active reading process. In science, active reading is a fact-finding process to support claims and develop reasoning (Porter-O'Donnell, 2004).

Admit Strips

To activate student thinking, teachers can present students with a writing prompt upon entering the classroom. This prepares students to engage in the academic language expectations for that day. Fisher & Frey (2019) noted that when students engage in the practice of writing in an academic setting, they engaged with content and developed a greater understanding of the material. Using these admit strips- strips of paper with a writing prompt increased student discourse with academic language (Fisher & Frey, 2019).

Incorporating a discussion component to admit strips can help to increase student participation and success when navigating scientific discourse which can improve writing. Wright and Gotwals (2017) researched talk in science classrooms and offered suggestions for increasing content conversations in the classroom as a means of improving literacy. One suggested component was the use of Adapted Primary Literature (APL) about a phenomenon to be studied in class. Students were provided with suggested questions to guide a discussion with peers about the piece of APL and then individually construct a written response. The opportunity to discuss before writing lent to a more in-depth and well-thought-out response to the admit strip question (Wright & Gotwals, 2017).

Graphic Organizers

Note-taking in science is an essential practice. Whether in the context of reading complex text or recording observations, it is a key part of acting like a scientist. However, students often do not know how to take good notes. Along with the explicit instruction of annotating, students

need to be guided on the process of taking notes. Note-taking should not be inclusive of all information, yet students will write everything down; notes should serve as a reminder of what was read or discussed (Fisher & Frey, 2019).

One way to help students improve their note-taking skills is using graphic organizers. Using a graphic organizer requires students to reread and engage in critical thinking about what they have read. Gillis (2014) gave an example of a heuristic chart that could be used to help students organize their thoughts about reading. This heuristic had students identify information within text that is an observation, infer its importance and then draw a conclusion based on the observation (Gillis, 2014). This helped students develop the thought processes they will need to write Claim-Evidence-Reasoning statements later.

Double Entry Diary

The double-entry diary is a strategy that helps students to find connections to their reading. When students find ways to connect to text, they are more likely to return to the text and read it more thoroughly (Tovani, 2004). Tovani (2004) utilized these double-entry diaries as a way for students to organize their thoughts and find connections within a reading. Students found a quote or section of the article and attached a personal connection to that quote. This can be used in a science class as way for students to organize evidence to support a claim (Tovani, 2004)

Porter-O'Donnell (2004) offered alternatives to in-text annotation in the form of a Dialectal Journal that is like the Double Entry Diary proposed by Tovani (2004). Similar to the Double Entry Diary, students wrote down a fact or quote from their reading on one side of the paper and used the other side to add commentary or reasoning if using it to construct a Claim-Evidence-Reasoning argument (Porter-O'Donnell, 2004).

Concept Maps

Concept mapping is a method to visualize the structure of knowledge. The use of concept mapping can extend and enrich students' learning by helping them to draw connections to prior learning and expand their current understanding of content (Asan, 2007). Concept maps are used as a learning tool and to help young students visualize the interconnectedness of scientific information, and they drive achievement. Asan (2007) found that concept maps helped improve student achievement among 5th-grade students.

Additionally, concept mapping can be used as a method of formative assessment and provide teachers with feedback about student learning before they take a summative test or even move on to a new topic. Choudhary and Bano (2022) found that using concept maps improved student engagement and interaction and teachers provided immediate feedback and addressed misconceptions. As a formative assessment tool given at the beginning of the lesson, they provided valuable feedback as to student prior knowledge as well as how students progressed through the lesson as the concept map grew. One strategy for emerging bilingual students is the use of cognitive maps that are student-constructed rather than teacher-formatted (Fisher & Frey, 2019). Having students construct them together and use them as anchor charts in the classroom for future reference can enhance understanding and, through vicarious experience, improve efficacy Bandura (1977).

Conclusion

As shown in this literature review, there exist a large body of research over self-efficacy as well as research on the complexities of scientific language and disciplinary literacy. There is not extensive research on ways to improve self-efficacy or how the instruction of disciplinary literacy strategies may help student efficacy in science. This research hopes to examine the effect

of efficacy from the instruction of disciplinary literacy strategies.

Chapter 3: Methodology

Frameworks

Pragmatism as a Theoretical Framework

As an epistemology, pragmatism defines knowledge as coming from the reflection of an associated experience or action (Riga, 2020). It is a way of knowing that supports the problems faced daily, with consideration of human action. The heart of pragmatism is the human component and idea that reality and truth lie within the individual experiencing and processing said knowledge. A pragmatist seeks to find working solutions to problems that are presented and bring a human aspect to the solution-finding process (Biesta & Burbules, 2003). For knowledge to be gained, an individual must have an educative experience, meaning the experience must not only yield growth but also create conditions for further growth. It is this concept of growth fostering further growth or learning fostering further learning that highlights knowledge as an ongoing process of attaining more knowledge in this philosophy (Dewey, 1938).

As a research approach, pragmatism in research is a theory of action that allows the researcher to apply understanding or meaning to an action or concept. Understanding comes from the experience of doing whatever is being researched (Riga, 2020). Pragmatism frames research from the perspective that action yields knowledge, and knowledge can inform action. This is a practical approach to educational research that allows educators access to knowledge that can inform their everyday activities. It emphasizes that the purpose and process of conducting research are of equal importance to what is being researched and that the ongoing understanding of the action grow. While early theories of pragmatism in research are attributed to American philosopher Charles Sanders Pierce, it was the applications and further definition of the research approach by John Dewey that ultimately framed pragmatism as an effective

approach to research in education (Biesta & Burbules, 2003).

Action Research as a Practical Framework

Through the lens of pragmatic action leading to knowledge, action research is well-suited as a methodology to explore the question posed by this study. Action research allows for the adjustment of interventions based on student feedback during the investigation. Because action research enables students the opportunity to reflect on their experience, it creates space for them to be metacognitive about their own learning. Additionally, the researcher can reflect on teaching practice to improve student interventions and grow as an educator (Herr & Anderson, 2015).

Action Research as an Educational Research Paradigm

Traditionally, there is a divide in educational research where researchers are producers and teachers are simply users of prescribed knowledge. Action research changes this. It began as a method of research that is conducted by teachers with the students. In education, action research provides a bridge from theory to practice. It provides an avenue for theory to inform practice and for practice to inform the improvement of theory (Biesta & Burbules, 2003).

Teacher as Researcher

Positioning teachers as researchers allows practitioners to conduct research and apply an action to the students they teach and within their own context. Teachers can then share research results with colleagues and use the knowledge gained to improve practice and further research on a specific topic (Hendricks, 2017). This concept is not new but was used during the late 19th and early 20th centuries because teachers were on the frontlines of education, and their classrooms were viewed as laboratories to carry out theoretical approaches to teaching and learning (Herr & Anderson, 2015). In general, teachers carried out the experimental duties set by university researchers, and by carrying out the research of others, steps were made towards allowing

practitioners to inform and contribute to theory (Herr & Anderson, 2015).

The 1970s and 1980s brought a resurgence of teachers as researchers in the United Kingdom. Laurence Stenhouse is generally credited as the catalyst of this movement at a time when British teachers were pushing back on mandated reforms they were expected to implement. The Stenhouse movement received a lot of resistance from traditional researchers for its lack of transferability. However, while action research is not usually generalizable the knowledge gained by doing this research can be transferred to other settings (Herr & Anderson, 2015).

Benefits of Action Research

Action research in education is a reflective process that is done by teachers with students and never to them. It is a form of research that requires deliberate planning to address a specific problem within a group or organization. Teachers who conduct action research are ideally situated to respond to the needs of students as the research is being conducted. They are directly connected to the research environment and subjects, with the most access to data that informs the research and action research cycle (Farrell, 2003). Additionally, by engaging in action research, teachers are focused on implementing best practices that most benefit their students and are empowered by their participation in research (Farrell & Weitman, 2007).

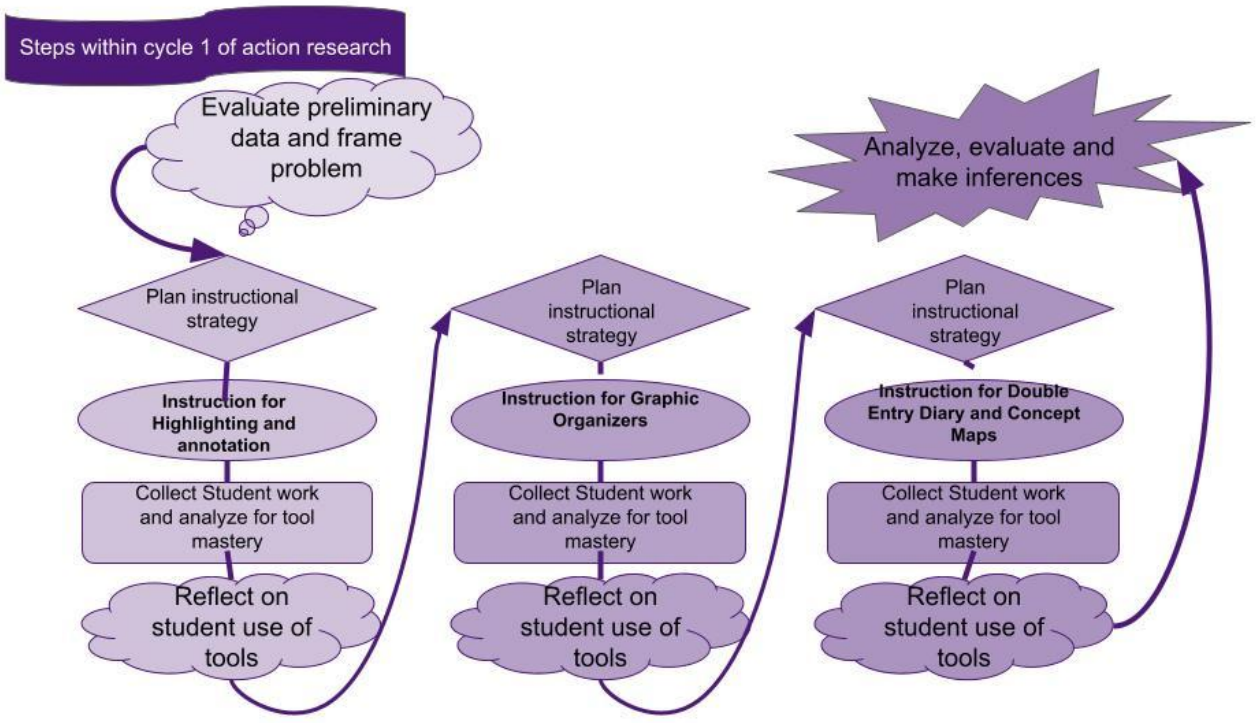
Action Research Cycle

The action research cycle used in this study (see Figure 1) is adopted from Hall et al. (2017). While their study was not conducted in an educational setting, the parameters and design intentions matched this study well. The current study covered a three-stage process within one action research cycle, and each stage lasted approximately three weeks depending on student response and ability to demonstrate mastery of the skill presented. Before the start of stage one, the demographic data of study participants were reviewed, and all participants were given a

preliminary student self-assessment to rate their science self-efficacy through a district-owned Qualtrics account (Appendix A). Students then completed a pre-test that asked them to use available supplies such as Post-it notes, highlighters, and scratch paper to help formulate a Claim-Evidence-Reasoning statement from a sample of adapted primary scientific literature (Appendix B). This information was used to plan the implementation of the first classroom intervention.

Figure 1

Action Research Cycle Adapted from A Toolkit for Participatory Action Research, by Hall et al. (2017). This cycle demonstrates the reflective nature of the project as well as the framework that was followed.



Method

After a review of the preliminary data, disciplinary literacy instruction was integrated

with content specific information. Students received instruction on one or two disciplinary literacy tools during each stage and practiced using them while working with biology content. The goal was to have students learn about the tool and then apply the tool to a scientific text or do some scientific literacy-based tasks this new tool or strategy. Providing feedback throughout this process helped to inform their level of mastery of the tasks in each cycle. When 80% of students demonstrated that they could use a particular skill or tool set, the next stage began with introducing a different disciplinary literacy tool.

Context Description

Prior to beginning this study, a campus-wide initiative to incorporate literacy instruction across the curriculum was instituted at North Texas High School (pseudonym). Using disciplinary literacy in biology as a curriculum intervention can assist students in formulating an argument about scientific research by writing a Claim-Evidence-Reasoning paper based on a sample of primary scientific literature. Research has established that infusing literacy instruction into science teaching equips students with specific interventions to find evidence within primary scientific literature but does not examine how it affects student self-efficacy (Cervetti & Pearson, 2021; Chatzikyriakidou & McCartney, 2022).

This study was conducted in a biology classroom at North Texas High School, a medium-sized urban high school in North Texas. At the time of this study, the school served students between the ages of 13 to 19 and provided schooling for the 9^{th} through 12^{th} grades. North Texas was a Title I school, and 94% of the student population was economically disadvantaged. School performance on standardized science tests was below the state averages (US News & World Report, n.d.). School attendance was determined by student address and enrollment in one of five specialized programs of choice (NSHS, n.d.). While 97% of the student population was considered minorities, there was not considerable ethnic diversity as 93.6% of the student body was Hispanic, 3.1% Black, 2.1% White, and less than 1% Asian. The gender of the student body

was 51% female and 49% male. The demographics of the students included in the classes for this research were reflective of the student body as a whole.

Participants

The students in this study were a convenience sample of those already enrolled in the class with the researcher. These students were enrolled in honors biology for the duration of the study. The biology classes being used for research had 24 to 27 students in each of the three sections, and 40% of the students were male and 60% were female. Within this group, 47% were identified as Emerging Bilingual students who received monitoring and assessment for English proficiency. Of the 78 students enrolled in these classes, all students completed the pre-and post-test assignments, but only 55 completed both the pre-and post-assessments on efficacy.

Recruitment

Parents of students who were enrolled in the biology class taught by the researcher were notified of the study by letter (Appendix C) which was delivered to students by the teacher during class. Students were informed about the research during class and had the opportunity to ask questions of the teacher. The letter to parents also had a parent permission form attached (Appendix D) and the child assent form (Appendix E). Parents were invited to back-to-school night, during which the lead researcher provided details about the purpose of the study. She addressed questions from student(s) and parents at that time. Students were instructed to return completed forms within one week. Paperwork was collected in a secure drop box on the teacher's desk. Parents and students were encouraged to direct questions at any point during the research to the lead researcher via email, phone call, or in person before, during, or after class time.

Students who chose not to participate in the study still received instruction in disciplinary

literacy tools for science, completed all assignments for the class, and reflected on the application of disciplinary tools to reading in science. Students opting to participate in the research were not required to do anything more than their classmates who were not participating but did have class assignments evaluated for this study.

Data Collection

Student data were collected as part of regular class requirements. Multiple data sources were used to ensure trustworthiness. The sources included demographics, a pre-posttest Claim-Evidence-Reasoning statement, pre-, interim-, and post-self-efficacy student self-assessments, student group reflections, and reflective journals for assignments.

Demographic Information.

Students' demographic information, grades, and test history were readily available to the researcher as their classroom teacher. This information provided insight into each student's academic achievement in science courses historically, revealing areas where improvements could be made and areas where they lacked efficacy. The students in the course were varied in their science abilities on state tests. Most students were below grade level for reading, but all were at the level of approaching grade level on the 8th-grade State of Texas Assessments of Academic Readiness (STAAR) exams for science. Twenty-two students were at grade level and eight students achieved masters grade level in science on their 8th grade STAAR exams.

Pre-Posttest Claim-Evidence-Reasoning Statement.

At the beginning of the study period, students were evaluated on their ability to take an authentic scientific research paper and make a Claim-Evidence-Reasoning statement based on the evidence and study information (Appendix B). After the 12-week study period, students were again evaluated on their ability to utilize the tools within the text to get an improved

understanding of the concepts and research. These tools were part of the concept of disciplinary literacy and required students to evaluate existing data to draw conclusions and express them the same way practicing scientists do.

These pre- and post-test Claim-Evidence-Reasoning statements were evaluated using a rubric (Appendix F). The rubric was designed to measure the strength of the argument based on how well the data supported the claim made by students. Disciplinary literacy tools used during the post-test phase informed the researcher about students' abilities to apply the tools they had been taught. The rubric was then loaded into Microsoft Forms, and student responses were recorded using this form. Responses from the forms were loaded directly into an Excel spreadsheet for further evaluation.

Student Self-Efficacy Assessments.

All students enrolled in biology at North Texas High School (pseudonym) took a six-question self-assessment (Appendix A) developed from the Metacognition, Self-Efficacy, and Learning Processes in Science (SEMLI-S) survey (Thomas et al., 2008). This assessment was presented to students and their families in the biology course syllabus (Appendix G) at the beginning of the school year. The initial instrument had five categories of science learning including control of concentration; constructivist connectivity; monitoring, evaluation and planning; self-efficacy; and learning risks awareness.

The six self-assessment items on efficacy were loaded into Qualtrics, and students were given a link to complete their assessment through the district-provided Learning Management System. The use of Qualtrics protected student confidentiality, encouraged them to respond more freely, and ensured the accurate recording of participant responses.

In addition to completing the full six-question assessment at the beginning and end of the

study period, students participated in interim assessment of three questions that relate to their feelings about their efficacy in the moment. Items one, three, and six from the original assessment (Appendix A) were used for these interim measures of efficacy and helped to guide the action research cycle. These responses were used to evaluate the impact of a particular strategy on student efficacy.

Student Group Reflective Conversations

Students periodically met in groups to discuss class topics. The focus of these conversations varied from discussions about the results from an in-class experiment, analyzing key points in a project or in response to how they applied a disciplinary literacy strategy they had just learned. These discussions were outlined in the course syllabus (Appendix G) and were recorded using the district-monitored Learning Management System and student devices. The researcher reviewed recordings to identify student misconceptions and demonstrations of student understanding, after which she used this information to inform the action research. Student discussions around disciplinary literacy often followed a discussion protocol (Appendix H) that assisted in informing the researcher on the progress of student self-efficacy and mastery of tool application. The structured discussions were modeled after focus groups as discussed in Fusch et al. (2022).

During the reflective group conversations, students followed a question protocol (Appendix H) and were in groups of two to four. Each group nominated a moderator to facilitate conversation and maintain the focus of the discussion (Fusch et al., 2022). Generally, discussions took no longer than 15 minutes and adhered to a semi-structured format. Conversations were audio-recorded to ensure the accuracy of transcripts. Student audio recordings were made using devices issued to the students by the district and turned into their teachers through the district-

monitored Learning Management System.

Initially these groups were assigned by the teacher but students in special populations (e.g., emerging bilinguals, special education, or 504) stated they felt uncomfortable speaking in front of some of their classmates. For this reason, students were allowed to form their own groups. This freedom of choice meant that not all groups were uniform in size but they still followed the same protocol.

Reflective Journals

Every two weeks, students were given a prompt to reflect on how the newly acquired disciplinary literacy skills shaped their self-efficacy in science. Prompts were constructed to help students answer questions about specific disciplinary tools they had been given (Appendix I). Often, these reflections were added as a final question of an assignment to prevent students from participating in the study from having work their non-participating classmates were not assigned.

Researcher Journal

Throughout the study period, the researcher kept a journal of observations. These observations included notes about student body language while using a new tool, conversations with students about disciplinary literacy, strategies for improving understanding of material, and discussions with other teachers around student behaviors as they related to student use of disciplinary literacy tools. This journal was used to inform decisions regarding the action research cycle and note observed changes in student self-efficacy behaviors.

Data Analysis

Both qualitative and quantitative data were analyzed on an ongoing basis as part of the Action Research model. The study did not seek to know if general science efficacy improved but specifically what changes in efficacy occurred due to disciplinary literacy instruction. Students

may not have improved their overall efficacy towards science, but they may have improved in one or more specific areas of science efficacy.

Qualitative

Schwandt (2001) described coding as an analytical, descriptive, or explanatory way to interpret data. In this study qualitative data were coded in two ways using *a priori*, context-sensitive method. Codes were first established based on existing research on self-efficacy with allowances to include the verbiage more commonly used by students. The codes derived from the literature included statements demonstrating increased motivation when performing a difficult task, excitement for being able to demonstrate a skill, recalling the successful application of a scientific principle to solve or understanding a difficult problem or issue, anticipating a good grade, the ability to explain a scientific concept, general comfort with difficult material, or phrases that demonstrate one's ability to meet the expectations of the class or assignment (McBride et al., 2020). These parent codes led to the development of subcodes that were more aligned with student vernacular and the actual verbiage of subcodes was derived through analytical evaluations of the study respondents. Examples of responses and coding can be seen in Table 1.

Table 1

Code book for student narrative responses.

Parent Code	Sub Codes	Examples
Increased Motivation for completing a difficult task	Positive (increased self-efficacy) Overall	"This is easy" "I can totally do this"
	The tool helped with an increase in efficacy	"After I highlight, it is so much easier to do this."
	Negative (decreased self-efficacy)	"I don't want to even try" "I can't" "I don't know what I am even supposed to do"
Excitement for being able to	Positive (increased self-	"OH! Let me show you…"

demonstrate a skill	efficacy)	"YES! I got it!" "This is my favorite…"
	The tool helped improve efficacy.	"If you make a graphic organizer for this it helps to see how it connects to that other thing we did last week."
	Negative (decreased self-efficacy)	"Why do I have to do this?" "I hate this…"
Recalling the successful application of a scientific principle to solve or understand problem or issue	Positive (increased self-efficacy)	"Oh, remember when… it's like that! You have xyz"
	Negative (decreased self-efficacy)	"I don't remember anything" "That was too long ago"
Anticipating a good grade	Positive (increased self-efficacy)	"I know I got an A on that."
	Negative (decreased self-efficacy)	"I hope it doesn't hurt my grade too much."
	Negative tool related	"I hope the graphic organizer isn't part of my grade. It did not make sense I didn't do it right."
General comfort with difficult material	Positive (increased self-efficacy)	"That was easy!"
	Negative (decreased self-efficacy)	"This is too hard. I'm never going to get it,"
Comfort in one's ability to meet the expectations of the class	Positive (increased self-efficacy)	"It's easy to lock-in in this class because I know I'll get it.
	Negative (decreased self-efficacy)	"I just don't ever know what's going on in here. Like I don't think I'll ever pass."

**Note.* These are examples of subcode responses and are not direct quotes of specific student responses.

The Microsoft Dictate tool in Word was used to transcribe audio recordings from the student devices in the school district Learning Management System (LMS) and reviewed by the researcher by playing back audio recordings to ensure the transcription's accuracy. Excel was used to track codes in student responses, and specific quotes were added to support coding choices. To protect student identities, identification numbers were used to organize data and names were removed. Consistent with the action research process, student reflective journal

entries (Appendix I) were transcribed into Microsoft Word to be coded for self-efficacy perceptions in science in an ongoing manner throughout the study to inform changes to the action research cycle.

The use of codebooks is a well-established practice when groups of researchers are examining data. Recent research has demonstrated the benefits of using a similar process for individual researchers doing qualitative analysis (Oliveira, 2023). Multiple codebooks were developed to evaluate the qualitative data in this study. The first codebook developed for this research used previously mentioned research on self-efficacy as evidence for the formation of the parent codes (McBride et al., 2020). Subcodes that further explain different expressions of self-efficacy or differing sources of changed efficacy in the verbiage used by students were noted and provided for deeper analysis of specific changes in student perceptions of success in class and changes in efficacy. For example, a student may have reported that they are good or not good at science when a particular task was too complex or that they were excited because they could achieve something they previously thought was too challenging. Student responses were coded and recorded as examples of overall efficacy change or tagged for task-specific changes in self-efficacy, such as in reading, writing, argumentation (Claim-Evidence-Reasoning), and overall science practices.

Student journal reflections supported decisions related to the Action Research throughout the study period. They were evaluated to assess students' perspectives on various tools and to assess whether the student used the tool correctly and whether they felt comfortable using it or not. The primary researcher evaluated student responses using the code book outlined previously in Table 1. Once student reflections described understanding and demonstrated that they could correctly use a tool, a different disciplinary literacy tool or skill was introduced. These

reflections also provided insight into how specific tools have impacted student self-efficacy and provide guidance along the research cycle.

Additional codebooks developed as part of the Action Research cycle and helped guide instructional decisions throughout the study (Appendix L). These codebooks tracked student use of tools on various assignments and tasks such as the pre- and post-test Claim-Evidence Reasoning. Another codebook developed as part of research evaluation was used to track common student responses during focus group discussions (Appendix M). For example, to analyze the question, "what is your favorite class?" the codebook categorizes responses according to English, social studies, science, math, or other to evaluate commonalities in student preferences.

To maintain trustworthiness, a second person spot-checked the coding of student data. This person was provided with the codebook and link to a Microsoft form that populated an Excel spreadsheet. The spot-checked data were compared to data coded by the primary researcher to ensure consistency with coding rules.

Quantitative

Descriptive statistics of the responses to the first student self-assessment (Appendix A) served as baseline data and provided an initial analysis of student responses. Means, standard deviation, and confidence scores for the whole group and individual responses were noted and recorded in Excel as measures of overall efficacy. Whole group statistics were analyzed to identify the impact of the instruction of disciplinary literacy tools. At the end of the 12-week study period, descriptive statistics were again calculated based on student responses to self-assessments. These were loaded into Excel for comparison. Changes in the mean of overall efficacy scores showed if there had been an overall increase in efficacy or whether it remained

the same. Examining changes in the means of each item on the self-assessment provided insight into what aspects of science self-efficacy had changed.

Interim self-assessments were also evaluated using descriptive statistics to evaluate the effect of specific interventions. This data helped to reinforce decisions within the Action Research and guide instruction planning. It also demonstrated where students self-efficacy at the midpoint of the study. The mean, standard deviation, and confidence scores for each administration evaluated to see the impact of the specific disciplinary literacy tool used as an intervention. Originally, interim data points were compared to the pre-and post-self-assessments however, because of the number of students who did not complete all three surveys it was mostly used to inform the Action Research and instructional decisions at the time.

Ethical Considerations

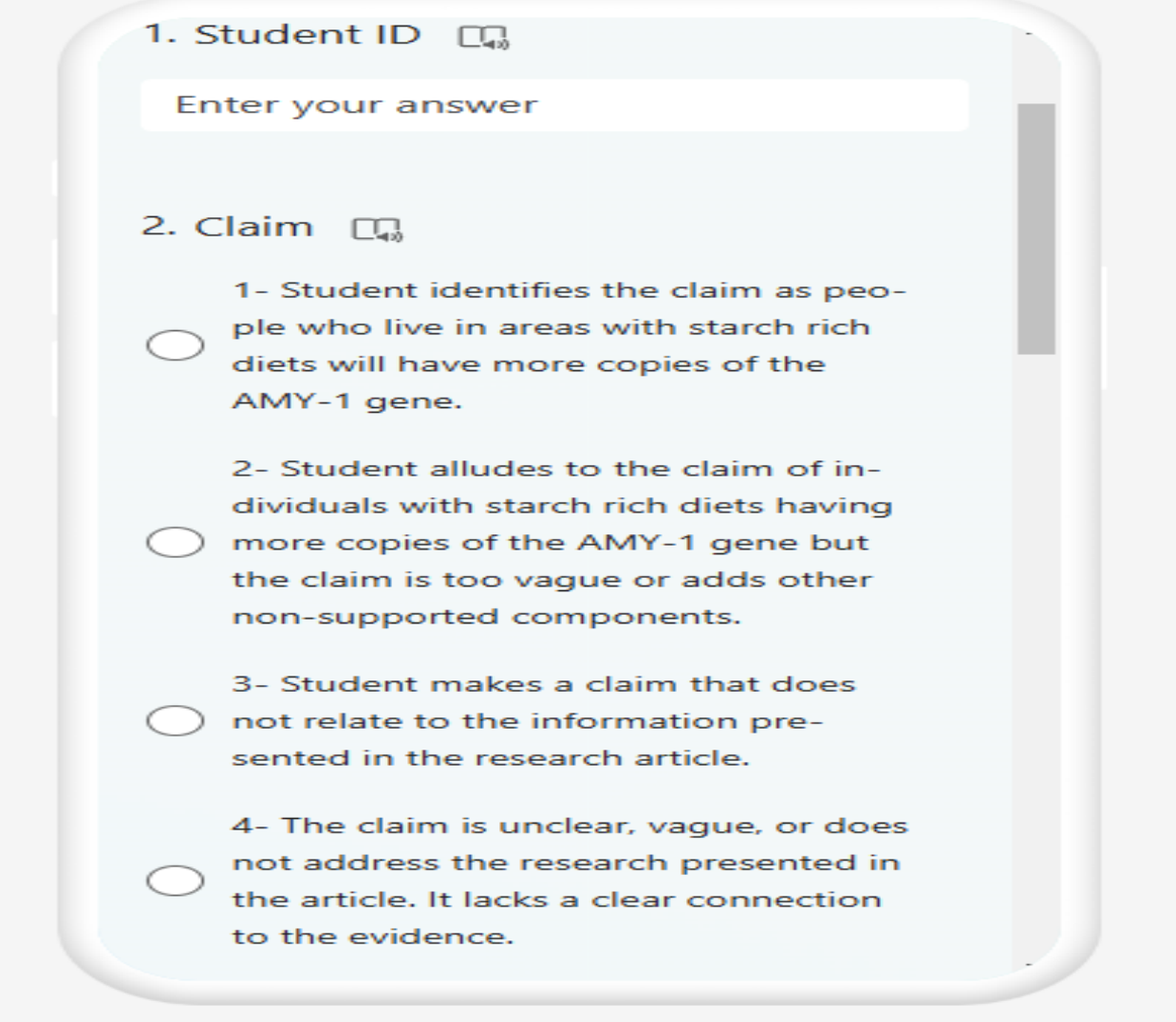
The teacher was also the primary researcher, positioning herself in the research as a participant and researcher. The teacher held a master's degree in science education. Her research focus for her master's was effective use of digital literacy tools in the science classroom. She had been teaching biology at North Texas High School for fifteen years and understood the course format and what to expect of the students. She effectively planned each research cycle to meet the students' needs and inform research. The teacher worked to develop student relationships and firmly believed in building trust and rapport with students to maximize student learning.

Being positioned within the research as a teacher with direct student connections and a stake in student success was challenging to navigate and has historically been a block for action researchers, specifically teacher-as-researcher studies (Herr & Anderson, 2015). The duality of being both the researcher and teacher delivering instructional strategies presents a dilemma of wanting to believe so much in the effectiveness of the prescribed interventions rather than being

able to see the data accurately. Various analysis protocols were included in the study to minimize the opportunity for bias. First, the assistance of trusted friends in discussing data interpretations provided objective insight and supported fidelity. One friend was a literacy professor and the other had recently earned a doctorate in science education. Both volunteered to review the researcher's interpretations of a data sampling and offer objective views. They did not have a personal investment in this study. They did have a professional obligation and level of expertise in literacy and science education that provided excellent guidance.

Second, a grading rubric to evaluate student pre-and post-test scores on the Claim-Evidence Reasoning responses. Rubric metrics were loaded into a Microsoft Form, as shown in Figure 2, and results were populated in an Excel spreadsheet. Rubrics provide a layer of objectivity when evaluating open-ended responses that have multiple possible ways of stating correct answers (Hendricks, 2017). The rubrics assisted in evaluating each student’s ability to effectively use the disciplinary literacy tools, such as highlighting with purpose and annotations to structure a response that communicated findings and stated claims backed with evidence and helped increase the reliability of these results.

Figure 2 Screen Capture of Part of The Microsoft Form Used for Rubric Entries



Note. The above screen capture shows how rubric metrics were put into a Microsoft Form that uploaded the results for each student into Excel, allowing for mean calculations, overall score summaries, and seamless data organization.

Third, data triangulation was facilitated by collecting multiple sources of data that demonstrated student progress, using a trusted friend to evaluate qualitative responses, and using a standardized rubric to evaluate student Claim-Evidence-Reasoning statements. By triangulating data, multiple sources were able used to better corroborate findings and increase credibility

(Hendricks, 2017).

Finally, to test the consistency and trustworthiness of the codes, a trusted friend spot-checked a random selection of transcripts from student group reflections and reflective journal prompts. She coded these using the established codebook. The results of the trusted friends coding were compared to data already coded by the researcher and demonstrated consistency with the codes and coding process.

Regulatory Compliance

To comply with all ethical standards, a completed Institutional Review Board (IRB) and a Collaborative Institutional Training Initiative (CITI) certificate for all involved in the research are available for review (Appendix J). The researcher was approved by the institution overseeing the research and the school principal provided a letter of approval to do research on the high school campus (Appendix K).

Parental Consent and Participant Assent

Parents were given permission forms to consent to their child's participation (see Appendix D). Students were also given an assent form for participation (Appendix E). Participants and parents were informed of any possible impacts of the study and were allowed to withdraw from participation with no consequence. This information was provided in both a letter home and through a question-and-answer session during back-to-school night.

Data Storage

Electronic data such as digital scans of student work, self-assessment responses, and transcripts of student group reflections are indefinitely stored on a password-protected and secure server. Hard copies of journals and student work were returned to students at the conclusion of the study. No hard copies of the student work were retained by researchers or any affiliated

parties with the school, or Texas Christian University. Electronic data access remains only available to the primary researcher of this study.

Chapter 4: Analysis

To address the two questions in this study (How does deliberate instruction of disciplinary literacy tools affect student self-efficacy? and What are the effects?), students were first evaluated for a baseline of their use of disciplinary literacy tools and given an assessment of their self-efficacy. Over the following 12 weeks, they received instruction on and practice with various tools to apply to scientific text and improve their reading ability in the discipline of science. Throughout the study period they reflected on their science self-efficacy.

Results

Results in this section are organized first by the method of analysis (e.g., quantitative, mixed-methods, and qualitative). They are then separated by data source and then within each section in the sequence in which they were collected.

The first data presented in this chapter are the descriptive statistics for the responses to the self-efficacy assessment (Appendix A). Students took this full assessment twice, at the beginning and at the end of the study period. The second data collected were various qualitative measures of student efficacy, including a pre-test on students' ability to evaluate an adapted scientific research article and write a Claim-Evidence Reasoning (CER) statement; transcriptions from student focus group conversations; and student reflective journals. The CER was used to plan instruction within the Action Research Cycle, but data also served as a baseline to compare the frequency that students used the tools. The next scheduled data collection occurred at approximately the midpoint of the study, students answered an abbreviated version as part of an assignment only using assessment items one, three, and six. The last scheduled data collection was a post-test on the CER.

Occasionally, students would write a reflection at the end of an assignment that included

a prompt asking them to reflect on the tool they were using and if it made the task they had just completed more or less challenging. Reflections also included student perceptions of the benefits of the task they had been learning about and how it helped them to learn.

Students also participated in focus group discussions about various disciplinary literacy tools they had learned about and how they impacted their view on doing science, understanding the scientific literature they were given, and whether the tool helped them understand the task they were completing. These attitudes were coded as positive outlooks associated with improved efficacy or negative outlooks associated with a decrease in efficacy. All recordings were collected as audio only, as allowed by IRB, and transcribed using Microsoft Word dictation tools. The coding of these responses was recorded using Excel.

Quantitative Analysis

Self-efficacy Assessment Results

The pre- and post-self-efficacy assessments were delivered to students as an independent task and not as part of an in-class assignment. The interim self-assessments were given to students as questions at the end of an assignment. Students did not receive a grade for participating and did not lose points for not responding to the questions. Because the pre- and post-self-assessments were not part of an assignment, not all students participated. As a result, there were more participants in the interim assessment than there were for the pre- and post-study assessments.

Pre-Study Assessment Results

Pre-study results of student responses to the self-efficacy assessment were evaluated using descriptive statistics. These results demonstrated that, overall, students did not believe they would be successful in a science course. Responses to this assessment were exported from

Qualtrics to Excel which was used to calculate descriptive statistics of mean, standard deviation, and reliability tests. The results of the preliminary assessment are presented below, along with commentary following the table (see Table 2).

Table 2

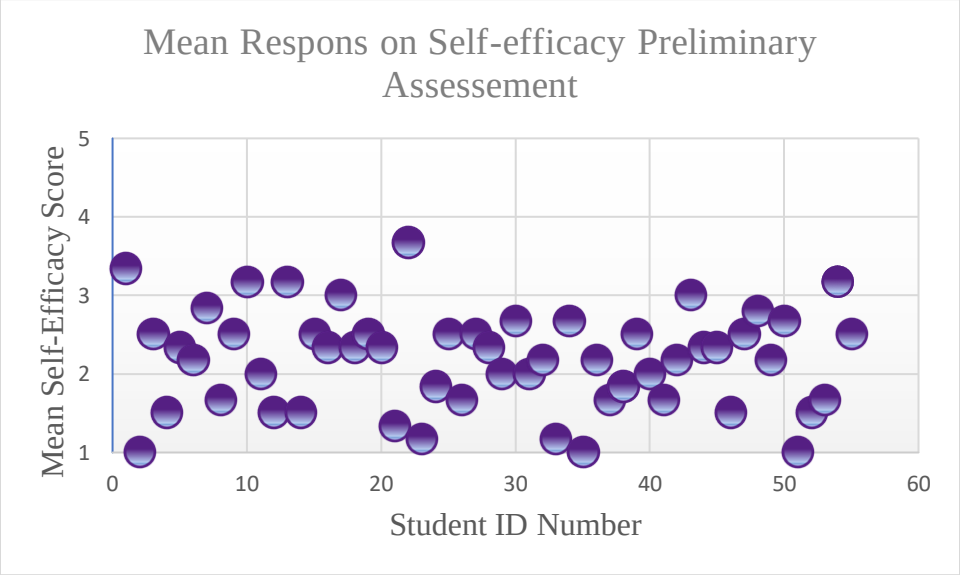
Mean of Responses to Preliminary Self Efficacy Assessment

Efficacy statement	Mean response score on a scale of 1 to 5	Standard Deviation	Confidence Interval of 95%
I am confident of understanding the basic concepts taught in this course.	2.0	0.816	1.78-2.11
I believe I will get an excellent grade in this course.	1.96	0.665	1.79-2.05
I know I can master the skills being taught in this course.	2.10	0.809	1.89-2.22
I am confident I can do a good job on the assignments and tests in this science class	2.05	0.803	1.84-2.16
I am confident of understanding the most complex material presented by the teacher in this course.	2.35	0.804	2.14-2.46
I know I can understand the most difficult materials presented in the readings of this course.	2.6	0.894	2.36-2.72
Overall mean score	2.18	0.629	2.01-2.27

The students reported their self-efficacy scores to be on the lower end of the five-point scale, and 50 of the 55 students disagreed (score of less than 3 on the five point Likert scale) with the positive efficacy statements (Figure 3). Highest ratings of efficacy came from the item that matched reading in science. Student scores were at an even two for the statement, “I am confident of understanding the basic concepts taught in this course,” yet the mean was 2.35 for

item five with the statement, “I am confident of understanding the most complex material presented by the teacher in this course.” Students were not sure they could understand the basic concepts but disagreed slightly less about whether they could understand the most complex concepts.

Figure 3 Individual Mean Scores on Preliminary Self-Efficacy Assessment



Interim Self-Efficacy Assessment Results

During week seven, students took an interim assessment at the end of a reading assignment (Table 3). Responses were added to Excel which was used to calculate descriptive statistics of mean, standard deviation, and reliability tests. Because this assessment was embedded in an assignment and not as an additional task, more students responded than with the initial and final assessments. Therefore, the data from those assessments could not be directly correlated to this assignment, and a test could not be conducted to test for the significance of the changes in the mean.

Table 3

Mean of Responses to Interim Self-Efficacy Assessment

Efficacy statement	Mean response score on a scale of 1 to 5	Standard Deviation	Confidence Interval of 95%
I am confident of understanding the basic concepts taught in this course.	2.14	0.875	1.89-2.39
I know I can master the skills being taught in this course.	2.29	0.944	2.02-2.56
I know I can understand the most difficult materials presented in the readings of this course.	2.71	0.824	2.48-2.94
Overall mean score	2.38	0.692	2.18-2.57

At the study's midpoint, students demonstrated an increase in the mean of their overall self-efficacy. There was a large increase in the efficacy rating for reading (item six) from the pre-study assessment to this midpoint assessment.

At this point in the study, 80% of students had demonstrated mastery on their use of highlighters and annotations, had begun using teacher created graphic organizers for taking in-class lecture notes, were using these graphic organizers with a reading task, and had just started learning to create their own graphic organizers. Initially, students were scheduled to complete this interim assessment twice. The first was planned during week three and the second during week nine, unfortunately, additional testing from the school district interfered with the schedule. As a result, the first interim study was dropped, and the second was rescheduled for the middle of the study rather than at the onset of the last quarter.

Results for the interim assessment showed student perceptions of their success with complex reading material increased as did their overall perceptions of efficacy. There was also an increase for item one which was their perceived ability to master skills being taught in class, however this increase was smaller than items six and the average of all three.

Final Self-Efficacy Assessment Results

The final assessment had 55 respondents who used the same random number as they had in the pre-study assessment. Students tended to disagree less with the positive equity statements at the end of the study than they had at the beginning (see Table 4).

Table 4

Mean of Responses to Final Self-Efficacy Assessment

Efficacy statement	Mean response score on a scale of 1 to 5	Standard Deviation	Confidence Interval of 95%
I am confident of understanding the basic concepts taught in this course.	2.13	0.747	1.93-2.32
I believe I will get an excellent grade in this course.	2.13	0.747	1.93-2.32
I know I can master the skills being taught in this course.	2.38	0.804	1.89-2.22
I am confident I can do a good job on the assignments and tests in this science class	2.31	0.865	2.10-2.56
I am confident of understanding the most complex material presented by the teacher in this course.	2.69	0.920	2.45-2.93
I know I can understand the most difficult materials presented in the readings of this course.	2.75	0.927	2.50-2.99
Overall mean score	2.40	0.629	2.01-2.27

The descriptive statistics for this assessment indicate that all measures were within a 95% confidence interval. The mean for all items was 2.18 (SD= 0.63), with a 95% confidence interval ranging from 2.01 to 2.27.

The final measure showed increases in self-efficacy across the board. Students

demonstrated an increased belief that they could do a good job both in class and on the assignments. They improved in their perceived abilities to carry out the skills expected of them and to be able to demonstrate mastery of coursework. They also showed increased self-efficacy regarding their ability to manage the reading expected in the class. The standard deviation of 0.629 showed that student averages were generally close to the mean of 2.40, up from 2.18.

While the overall mean efficacy scores increased, some students reported a lower self-efficacy score after the assessment than before. For the final assessment, 13 of 55 students had a decreased score. Of these 13 students, only four reported that their perceived ability to understand the most difficult materials presented in this course's readings had decreased.

Mixed Methods Evaluation

Qualitative data were evaluated using codebooks to quantify the frequency of student responses that demonstrated positive or negative changes in self-efficacy (see Table 1) to determine how often students applied tools to use on assignments, such as the pre- and post-test Claim-Evidence-Reasoning statement (Appendix L) and to track common answers during the focus group discussions. The parent and subcodes from these codebooks were used to create Microsoft forms to accurately tabulate frequency of each code into Excel.

Pre- and Post-Test

To establish a baseline for student use of \ tools, students were given a pre-test that asked them to write a Claim-Evidence-Reasoning statement (CER) of an adapted primary scientific research article. Using the codebook for evaluating tool use, zero students correctly applied disciplinary literacy tools to the scientific text and struggled to write effective Claim-Evidence Reasoning statements. Fewer than 50% of students opted to use highlighters, and no student utilized scratch paper to create graphic organizers or Post-it notes to annotate their papers.

The researcher used data from the pre-test to construct an instructional calendar and timeline for the action research cycles (Figure 4). Mastery of skills was measured throughout the instructional process before moving to a new skill. Once 80% of students demonstrated mastery, a new skill was introduced.

Figure 4 Planning Calendar for Implementation of Disciplinary Literacy Tools

Week of study	Disciplinary Literacy Tool	Assessment	Demonstration of mastery of skill
1	Adapted Primary Literature	Claim-Evidence Reasoning Pre-test	Pre-test- Mastery not expected
1-2	Functional Highlighting- Highlighting with a purpose	Reading samples for bell ringers and exit tickets Anchor texts explaining scientific phenomena	Students can use 2 colors of highlighters to effectively: • identify key phrases with one color • link information from graphs, figures and diagrams to in-text information. • Find answers to questions when given • Identify claims in research
1-3	Annotations	Reading samples for bell ringers and exit tickets Anchor texts explaining scientific phenomena	• Students can elaborate the information highlighted by providing content knowledge or understanding. • Students can note pieces of evidence that will support the researchers claims and provide reasoning in annotations
3-5	Teacher designed Graphic Organizers	Graphic organizers used in class to organize notes, outline processes and reinforce concepts	Students can accurately pull information from text, lab or demonstrations to complete graphic organizers such as • Venn Diagrams • Data tables • Diagrams of scientific processes • Double-entry diaries

5-9	Student designed Graphic Organizers	Class notes Anchor text responses and analysis Lab and class demo analysis reports	Students use teacher-modeled graphic organizers to create their own to: • Organize lab data • Develop claims • Link concepts to one another to explain phenomena • Diagram scientific processes
9-10	Concept-mapping (teacher modeled)	Anchor text responses and analysis Analysis of lab activities and demos Lecture notes	Students accurately complete concept maps to link scientific concepts and theories
10-11	Student created Concept maps	Anchor text responses and analysis Analysis of lab activities and demos Lecture notes	Students can design their own concept maps to: • Link different content lessons to an overarching concept • Find similarities between different scientific concepts • Develop links between research-supported evidence and existing scientific concepts to develop reasoning for CER statements
12	Adapted Primary Scientific Literature	Claim Evidence Reasoning statement	• Students will apply 70% of the above tools to effectively write a Claim-Evidence-Reasoning (CER) statement using primary scientific literature. • Students will apply content knowledge to support their CER statement.

For the post-test, students were given the same piece adapted scientific research article and asked to perform the same task of identifying the researchers' claim and evidence and giving reasoning as to how the evidence supported the claim. Just as with the pretest, students were given access to Post-it notes, highlighters, and scratch paper. Based on notes in the researcher's journal during the post-test, and using the tool use codebook (Appendix L), all students chose to use a variety of the supplies offered. Some opted to take all of them, while others appeared to select only the tools that supported their preferred disciplinary literacy tool. Students

demonstrated confidence with using various tools, but the choice of which tools they used varied from student to student. For the final product that they turned in 96% used at least one highlighter, about 68% used annotations in some way, about 25% used a teacher created graphic organizer and a little over 10% created mind maps before writing out their final product.

After completing the post-test, students participated in focus group discussions in groups of their own choosing. They discussed their feelings about the post-test and how they viewed their self-efficacy in science class. These discussions were recorded and evaluated with other qualitative data.

Qualitative

Focus Group Discussions

Students participated in focus group discussions (titled conversations in class) in groups with classmates of their choice. For the most part, these conversations were student-led. However, the lead researcher would occasionally redirect the conversations if they drifted too far from a discussion about self-efficacy and their views on science class.

Another codebook and Microsoft form (Appendix M) were used to facilitate evaluation of the frequency of common responses found in transcriptions of student focus groups. An example is the answer to what is your favorite and least class? During the initial focus group discussion, 37 of the 78 students reported that science class was their favorite class. Twenty-three of those 37 who stated science was their favorite class also said they found science to be complicated. However, students noted that the difficulty of the material did not detract from enjoying the classes and finding science interesting. Student 37 stated that, “Don’t get me wrong, science is cool. It’s just so hard.” This sentiment was reinforced by student 33, who said, “I like science and it’s fun to do sometimes. I’m just not good at science.”

After coding focus group responses, 19 of the 38 students reported that science was their least favorite class. Overwhelmingly, these students reported that it was their least favorite due to the difficulty of the content, finding it hard to understand the information, and that the reading was particularly challenging. They also noted that it required significantly more effort for them to grasp the material. For example, when asked about their least favorite class and to explain why Student 49 stated, “Science is my least favorite class- I’m sorry Miss, when you listen to this. It just is. Like science is cool and all, but it’s just too confusing.”

Another, Student 15, reported, “For me because it's something that I really don't get quickly, it makes it so I don't like it as much. I am afraid I can't do it, so I just start to not like it." They expressed that they want to like it more, but it’s just so difficult for them to really know what is happening. They said their favorite class was and always has been music because they feel confident doing it.

At the end of the study period, Student 15 reported:

> Science is still hard, and I still get nervous that I don’t know enough about things. But it helps to have strategies to help it make more sense. I feel better when I try to do it. But Mariachi is still my favorite class.

After learning to apply disciplinary literacy tools to scientific literature, 19 students indicated that they enjoyed science more and that the reading aspect was no longer as daunting as they had once viewed it. In the final focus group discussion, 72 of the 78 students stated that the tools were helpful and made the hard stuff easier. Student 38 shared that their favorite class at the beginning of the year was English because they loved to read. They acknowledged that reading was a huge part of doing science but that it was different in science, harder in a sense and that they had a hard time following. In the end of study focus group discussion, Student 38 said,

> Biology is now one of my favorite classes- almost as much as English. Now, when I read, I see it as a mystery that needs to be solved, and the highlighting and stickies and annotations are how I can organize clues to solve the mystery.

Student Reflections

Student reflections provided a deeper view as to how each disciplinary literacy tool impacted their self-efficacy. Reflection questions were embedded into assignments that required students to utilize the tools we were currently focusing on. There was more participation for these reflective activities than the self-assessments because they were embedded in assignments they had to turn in for a grade rather than a separate task.

Highlighting With Purpose

Consistently, students said that highlighting was the tool they found to be the most helpful and easiest to apply in various settings. Student 62, commented, "Highlighting with purpose helped me a lot, it really helps me keep track of the things i need to know and what information is most important." Another, Student 35, commented on how highlighting made a task easier to achieve, "Highlighting helped me be more organized and find what I was looking for and it made it a lot more easier for me to look at the important things or what the main idea was about the article."

For this tool, the class discussed the purpose of highlighting and how you apply that purpose to action. For example, when reading an article for purely informational purposes, the action is to highlight key facts and vocabulary. If the task is to identify or state a claim and support the claim with evidence, then the action is to highlight the claim in one color and supporting evidence in a different color. Students learned that when highlighting, they must first identify their purpose to be the most successful.

Students demonstrated mastery of this skill in the scheduled amount of time and used the skill consistently on all reading tasks. Students were not only able to demonstrate mastery in class but could also utilize the skill in other classrooms. On one occasion, noted in the researcher's journal, students were doing a review on cancer in another classroom. The teacher gave them an article to read and made sure to have Post-it notes and highlighters available so they could practice with the disciplinary literacy tools they had learned in class. Students picked up their supplies and began highlighting key points and vocabulary. After about five minutes, the teacher realized that they had forgotten to post the questions that went with the article. They quickly posted them, and the students reacted in dismay. Student 32 frustratingly asked for a new copy of the article because, "I highlighted the whole thing for the wrong purpose and now I need to do it again. I highlighted for key points- not for questions!" This reaction demonstrated that students had developed a skill they were able to transfer into a different situation where they knew they were not being evaluated for their highlighting skills or expected to use disciplinary skills.

In a review of student reflections, 53 students stated that they found this to be the most useful skill and appreciated how much it helped them move through the reading as well as help them reference back on the information. Students reported that they were accustomed to using highlighters in English class and had been practicing with them for state end-of-course assessments. Despite the familiarity with highlighters, 46 reported never learning exactly what to highlight or how to use them as tools that help them when reading challenging texts. Students' reflections provide evidence that they now have a set process they follow with highlighters when they sit down to read, and generally, they need more than one color. In their highlighting reflection, Student 10 said,

> Whenever I use highlighters, I have 3 or maybe 4 different colors and this helps because each color has a different job, for example pink can be the color I use to highlight the claim, orange for evidence, yellow for reasoning, and green for other IMPORTANT information. This helps because it makes sure I have everything in my research well organized.

While this example was the most specific detailing of how the skill of highlighting with purpose was executed, it was not a unique occurrence. By the end of the study, almost 75% of students would select three or four highlighters from the classroom supplies when any reading was involved in an assignment, and all students will choose at least two different colors. A lot of students have purchased highlighters that have varying colors that match their individual preferences for thickness and point type.

Annotations

Annotations were a skill that received mixed responses. Some students believed using annotations gave them confidence when they had to write. Student 8 stated, "I never annotate. It takes too much time, and I end up just writing stuff twice." Others found that annotations helped them organize their thoughts or restate information in text. Student 36 said, "I used the annotations on my paper to help me explain my evidence better."

Some students found that writing out annotations on Post-it notes was extremely helpful when they needed to complete a writing task. Student 24 explained how they would use Post-it notes about evidence within an adapted primary research article to build concept maps, format Claim-Evidence-Reasoning statements, or organize essay responses:

> When I do my annotations on the sticky notes I number them and then take them off the paper I'm reading and sort them into the way I want to write my answer. I also used them

to explain my connections on mind maps. It was really helpful plus it made it so much easier when I had to write and made me feel so much more confidence about what I was doing. Plus when I take them off I write the numbers on my original paper so I can put them back where they went and can reuse the paper and notes- it's actually kind of perfect for me.

This student's self-assessed efficacy score increased by one-half a point from the pre-to post-test assessment. The increases were from their perceived ability to get a grade in the class and ability to do a good job on the tests and assignments (questions two and four on the SEMLI-S). The ability to make notations about what they had read in a way that they could manipulate and maneuver as they thought through their responses benefitted their ability to complete the task and improved their perception of how they would perform on that assignment.

Graphic Organizers

Students found that graphic organizers helped depending on the situation. Student 58 said, "They were hard and didn't really seem helpful, but sometimes they made things easier to organize my thoughts." Graphic organizers were introduced through class notes and were given to students before lectures. Students then would use the organizers to take notes and add information based on the presentation. They could then use these notes later for labs and informal assessments. After a couple of days, students were then given teacher-created graphic organizers to collect information from a reading on genetic disorders. These graphic organizers helped them to identify key pieces of information and write commentary regarding their relevance, which were used to complete projects.

Some students appreciated graphic organizers not only as tool to use while reading to organize information but also as review tools when preparing for tests or completing summative

projects. However, students would readily use teacher-created graphic organizers but were hesitant when designing their own; they did not even attempt without a lot of guidance. When asked, “Why not create a graphic organizer to help you organize this information?” Student 42 responded that they were, “not sure how to do it the right way and didn’t want to make the organizer wrong.” Through further conversations with students, the researcher found they did not feel comfortable fully designing their own, so an adjustment was made to the cycle that provided them with scaffolding. A design library was created that allowed students to pick a skeleton that fit their needs for a specific task they were working through. With access to the design library, the use of student-created graphic organizers increased, and students expressed more ease in using them. On accessing the graphic organizer design library, Student 66 stated:

“I like the example organizers on canvas. When I need to write something important I go into our class canvas and pick one that seems like it makes sense. I like that I can look them up even when I am in another class. Sometimes the stuff we use in here helps me in APHuG [Advanced Placement Human Geography] and my teacher is ok with it.”

Concept Maps

The final tool for which students received instruction was concept maps. These tools can be helpful when planning writing tasks, organizing information from research, and making connections between various topics we studied during the semester. Students were instructed on how to use concept maps to construct Claim-Evidence-Reasoning statements. The idea was that students would utilize this tool on their post-test. However, 64 chose other tools over this one. For the most part, students found concept maps to be difficult and frustrating. Student 19 framed what many students felt when they said, “Concept maps just don’t make sense. Why are the boxes where they are and connected to how they are? I just don’t think they make sense and get

confused and frustrated."

While 64 students did not choose to utilize concept maps, there were some who found that it helped them to better organize their thoughts. As was the case for Student 61, "When I use a mind map, it helps me to see how everything makes sense together because otherwise it's all confused together in my head. These make it so I realize that I do know the science stuff."

This is one skill that students may benefit from more time being dedicated to instruction. The time frame as originally planned would have allowed students more time to develop understanding and practice using concept maps. However, schedule disruptions from everyday school occurrences shortened the window of instruction.

Reading Adapted Primary Literature

In student responses to reflections on reading assignments, they described reading primary scientific research as "confusing and didn't always make a lot of sense," according to Student 43. Or that "the writing is hard to follow and when I look up words I forget where I was and have to start over again" (Student 19). These statements are aligned with existing research on the language of scientific texts. Plus, most research articles are written well above the reading level of a high school freshman. Presenting them with reading material that had been adapted to a reading level that they were more comfortable with but was still scholarly in nature provided them a pathway to learn through experiencing scientific literature.

Over the course of the study the adaptations of literature were scaled back and by the end of the study students would find articles on the National Institutes of Health research database and were able to navigate the articles with less hesitation than they had at the onset of this study. When asking if an article about Down's Syndrome they had found on the Center for Disease Control website was appropriate for a research project, Student 31 said, "I never thought I'd be

reading stuff like this in high school and it still hard but I know how to take it apart now so it's not as bad. But still a little bad." This student had a full two-point increase on their ability to understand the most complex material in the course and mean increase of one full point. Additionally, at the end of the study, this student volunteered to answer questions aloud and frequently asked very thought-provoking questions in discussions. These were both behaviors they did not engage in at the beginning of this study and demonstrated an increased confidence in class.

Summary of Findings

Research Question 1: What are the effects of instructing high school students to use disciplinary literacy tools to read scientific literature on science self-efficacy?

For the first question there was an increase of science self-efficacy in all areas. There was a statistically significant increase in students' perceptions of knowing they can master the skills taught in the course, confidence that they could do a good job on the assignments and tests in science class, and understanding the most complex material presented by the teacher in the course. There was an increase, although not statistically significant, in confidence in understanding basic concepts taught in this course, believing they would get an excellent grade in the course, and knowing they could understand the most difficult materials present in the readings of this course. While there was a statistically significant increase in the ability to understand complex material, the increase was not significant even after learning and applying disciplinary literacy tools on students' perceived ability to understand the complex reading material.

The qualitative data supported these findings of an overall increase. Most students were positive when reflecting on their assignments or lessons and continued that positive tone in the

focus group conversations. Negative student responses tended to be on specific tasks and did not reflect their overall opinions of their perceived ability. Students who did have an overall negative view of their abilities in the course still said that some of the skills they learned helped them succeed when reading scientific literature and were able to formulate responses to scientific questions with more confidence. Additionally, most students equated their overall negative outlook to a lack of preference for science over other subjects.

Research Question 2: How does the deliberate instruction of disciplinary literacy tools affect student self-efficacy in biology?

When analyzing the second question, disciplinary literacy instruction appeared to help students build confidence and start to believe they could tackle difficult reading associated with scientific literature. Some tools had more success than others. For example, after learning how to highlight with a purpose and use the highlighted text to formulate responses to questions or support claims with evidence, students required less assistance to complete these tasks, and several commented in their reflections how it impacted their understanding of the material. This increased self-efficacy was also apparent in their ability to apply the tool in a novel setting with a different teacher. When students were presented with a reading and no guidance or prompting from the researcher, who was their regular classroom teacher, they still demonstrated the ability to master both highlighting and annotating successfully. This transferability demonstrated their confidence in the tool is a positive support for them.

Action Research

Interim Analysis Decision

The findings for the second question also influenced decisions around the action research cycle. Mastery of a particular tool was measured using rubrics in Microsoft Forms. Once students demonstrated 80% mastery the tool, another tool was introduced. Often, when students

had reached mastery, the efficacy-based responses in their reflections were more positive. For example, after the first reading using Post-it notes to add annotations, the reflections centered around how difficult the article had been and that they found the content hard. However, when they had achieved mastery, the reflections were about how the annotations on Post-its helped them organize their responses and helped them to write better. Students also alluded to how much easier it was to apply the information in the reading to what we were learning in class.

Mastery was, at times, more difficult to achieve than had originally been planned for, and that required adjustments to the planning calendar. For example, initially, two weeks had been planned for student-created graphic organizers. However, students struggled with this task. They found it difficult to move forward and create their own novel graphic organizers. Because of this struggle, more time was dedicated in the planning counter calendar to allow for students to adapt to making their own graphic organizers. This adjustment then meant there was going to be less time for concept maps, both student and teacher created. Had more time been allowed for students to really work with concept maps and apply them to difficult reading, there may have been an even more significant increase in self-efficacy as a whole and possibly a statistically significant increase around the difficult reading in the course.

Post-Study Revisions

The conclusion of this study coincided with the end of the semester and the beginning of winter break, which allowed for time to adjust any of the instructional methods employed during the study. These adjustments could be used in the following semester and the next phase of the action research cycle. The researcher asked students to make one suggestion for the upcoming semester on ways to continue to incorporate disciplinary literacy strategies into science. In general, students wanted to continue to use the strategies they were most comfortable with and

were willing to try learning more about concept maps.

While consistent monitoring of student self-efficacy will continue in the second phase of research, it will not be the primary focus. Additional measures to monitor will include student achievement and the ability to apply tools learned in class across the various scientific disciplines. For this next phase of research, students will continue to work with concept maps, and the introduction of more complex reading will be employed to see how students apply their previous learning. This higher-level reading will continue to be adapted from original primary research articles with the hope that by the end of this second cycle, students will be able to use primary research articles without any adaptations. Additionally, the next cycle will incorporate writing skills to go hand in hand with the reading skills students have already been practicing. The next cycle of research will be considerably shorter due to state testing.

Students also reported that they had never learned how to read for specific subjects or disciplines. On a campus that aims to incorporate literacy across the curriculum, it seems important that disciplinary literacy skills be taught in all scholastic contents. It is the hope that this type of instruction can continue with the vertical alignment of other science courses on campus as well as be expanded to include other disciplines.

Negative Case Analysis

While there was an overall increase in student self-efficacy, 13 students' self-efficacy decreased during this study. More in-depth discussions and broader prompts for reflections for these students could provide information on what factors led to their decreased self-efficacy in science class. That some students' self-efficacy decreased while others increased demonstrates that there is not one solution for all students and each student is an individual with individual needs to help them achieve to the best of their potential.

Chapter 5

This study sought to explore a possible connection between teaching students how to use disciplinary literacy tools and improved self-efficacy in science. Examination of the results showed that incorporating deliberate instruction of disciplinary literacy tools into a high school honors biology course did increase student self-efficacy.

Improved Self-Efficacy

Student self-efficacy in science improved during the study period. One factor that influenced this increase was increased comfort when interacting with the content, specifically reading about the content. The disciplinary literacy tools students learned provided them with a resource that made the written language more accessible and manageable. It was less intimidating for them to read primary research articles or access information from journals published by the National Institutes for Health or Centers for Disease Control.

Mastery Led to Increased Self-efficacy

Once students demonstrated mastery of a tool, their reflections tended to be more positive, indicating that achieving mastery yielded an increase in self-efficacy. This was consistent with research from Bandura (1977) that stated performance accomplishment as a source of improved self-efficacy. When an individual is able to perform a task well they have a greater belief that they will continue to do well. When students did not understand a tool or it was completely unfamiliar to them, they were quick to dismiss using it and quick to get frustrated with their own limited abilities. In other words, before they were able to demonstrate accomplishment with a tool, they doubted their probability of continued success. As they began to see practical applications of tools and got better at applying them to assignments, the value they saw in the tool increased, as well as their ability to perform with the tool led to the perception that they could achieve success increased. With an increase in self-efficacy students

were more invested in mastering the skills associated with highlighting or annotating or whichever tool the class was working on at the time.

Success yielded improved perception of ability and improved perception of ability then lent itself to improved application and mastery. Much like the results found by Scott (1996), when students experienced success, their perception of their abilities improved, and they found more joy in the activity. This was reinforced by Student 15's previously mentioned perception of science- as they improved in understanding scientific literature, they liked it more, but not as much as music because they demonstrated mastery consistently in music and only somewhat in science. When we are good at something, we tend to want to stay good at it or continue improving and believing that we can. When we are unsuccessful, it is easier for us to believe we will never succeed and difficult to find pleasure in participating in that activity.

Mismatch Between Assessment Results and Journal Responses

Student scores on their self-efficacy assessments indicated that they disagreed with statements that indicated a belief in their ability to succeed in biology. However, most of the commentary in the journal responses was positive, and they believed they would perform well. This was consistent with many students. Student 46 had an average self-efficacy score of 1.83 at the conclusion of the study and did not agree with a single item on the self-efficacy assessment. Yet they consistently noted in their reflections how good they felt about an assignment and how helpful they found the disciplinary literacy tools. In one entry, they said,

> Using mind maps on our project was so helpful. I was able to annotate my research from the CDC on post-it notes and then use those post-its to build my mind map. It was really great. AND I TOTALLY understood all of it. I'm really excited about all we are learning to do.

The next week in class, students completed the final self-efficacy assessment, and Student 46 strongly disagreed with the statement, I believe I will get an excellent grade in this class.

Qualitative reflections allow students to provide a richer, more contextually grounded understanding of their self-perceptions. They are far less high stakes seeming than even the most innocuous Likert scale based evaluation. Bandura emphasized that individuals' perceptions of efficacy are shaped not only by lived experiences but also by how those experiences are processed cognitively and emotionally. Because the reflection provided a less evaluative and more expressive way for students to connect with their perception of success in the class. This freedom of expression allowed them to acknowledge their potential in ways that traditional survey measures may not fully capture.

No One Tool Worked for Every Student

Not all tools were helpful to all students. Students would mention that some tools were more useful than others, that they did not like certain tools, did not understand specific tools, or really appreciated how one tool would complement another. This varied response by students provided insight into the difficulty of the task of building student confidence in themselves using a one-method approach and supported the decision to teach a variety of different tools throughout the study period. The need to employ multiple modalities to yield learning was consistent with the research by Roth, (1994). Roth discussed that a single mode of discourse was not sufficient to yield student learning. Similarly a single approach to disciplinary literacy was not enough for students to fully embrace the idea and to feel comfortable navigating material. Having the choice of tools and the method of application was where students demonstrated the most growth in their self-efficacy.

The consistency in the growth of student self-efficacy showed the benefit of integrating a

disciplinary literacy-infused approach to teaching biology. This finding is especially important for planning purposes. Not all students are going to respond to interventions in the same way and it underlines the importance for taking a deliberate and multidimensional approach for any education intervention. Had this study focused solely on annotations, mind maps, or graphic organizers, a large number of students would not have benefitted as they indicated that they did not see the point in those particular interventions and that highlighting really helped them focus on what was important as they read.

Honors Students' Low Self-Efficacy Ratings

The low self-efficacy scores on the self-assessment by honors students was an outcome that was not expected. All assessment scores were below three, indicating that they disagreed with statements indicative of positive self-efficacy. Of these students, 30% have been tagged as Gifted and Talented (GT) since elementary school. It was interesting that students who are among the top of their graduation cohort for achievement consistently disagreed with statements regarding the possibility of academic success on their self-assessments. The reasons for this were noticeable in the comments of their self-reflections, especially when learning a new tool. When the class started using student-created graphic organizers, Student 17 complained, "making my own graphic organizer is too hard and I don't see that it helps me learn anything." For the final CER this student made their own graphic organizer to outline the claim, each item of evidence and tied specific reasoning from class notes (also in graphic organizer form). In the final reflection they stated,

> I didn't like some of the tools too much to start with because I just didn't know how to use them. But with practice I found out I do like them, and they help me organize what I read so I understand it better. That helps me do better.

For this student when the tool was unfamiliar or they were not an expert at using it, the tool was not helpful and pointless to learn about. As they became more familiar, they found the tools to be great. This is reflective of many of the top students at North Texas who think they need to be able to perfect something right away for it to be useful or for them to be good at something. When they are not, they tend to find reason to dislike it.

From research on gifted and talented students, one possible explanation for this low self-efficacy rating despite being high achieving students could be related to heightened metacognitive awareness. Parjares (1996) noted that gifted students often have advanced self-regulatory skills. In other words, these students may have a deeper understanding of what is required to be successful in an honors science course, and their self-awareness makes them more cautious in rating their own ability to achieve mastery. So, their critical evaluations of their self-efficacy are not from a lack of confidence but more reflective of the fact that they know more of what they don't know (Pajares, 1996).

This phenomenon among gifted and talented students was further examined by Neumeister (2004). He found that gifted students' tendencies for perfection and high personal standards for achievement influence their self-perceptions. Because students in this demographic set exceptionally high standards for themselves, they tend to undervalue their good achievements that fall short of expectations they set for themselves. This was demonstrated in this study by the fact that 80% of the students tagged as GT maintained the same efficacy score from pre- to post-study. Nearly all of the 20% who demonstrated a change did increase their score, but only by a very small amount, and this was typically attributed to a one-point increase on one of the six assessment items. One GT student had a decrease in the average of their self-efficacy assessment score because they lowered their rating on the statement related to perceived ability to get a good

grade in the course. At the time, they had a B in the grade book, and it was not the final grade recorded on their final transcript, but at the moment, they had a B. In a journal entry, they also wrote, “The thing that had the most effect [on my confidence in this class] was my grades because if I had them low, my confidence would drop.” They perceived a B as a bad grade when, by most educational metrics, a B is considered above average.

Mindset theory also provides another lens to evaluate these low ratings. In the context of mindset theory, Dweck (2006) emphasized that students' beliefs about intelligence significantly impact their motivation and self-assessment. Some may see intelligence as fixed while others see it as malleable and capable of change and grow. Students with a growth mindset recognize that abilities can be developed through effort and learning. However, even within this framework, high-achieving students may report lower self-efficacy if they perceive the challenges ahead as substantial and view their current abilities as a starting point for further growth rather than a fixed measure of competence. Dweck herself cautions that student perceptions vary by context and may not always directly align with actual ability or motivation.

Pragmatic Consistency

Previous research has established a connection between high self-efficacy and achievement. What does not exist in research are ways to improve student self-efficacy in classroom settings. This research provides evidence of a tool that helped students make gains in their self-efficacy and improved their outlook on their abilities in biology class.

By employing action research in a classroom setting, a real-world precedent has been set that can serve as a model for future research. These skills were incorporated into the curriculum, and reading materials were often used as a mode for delivering biology-specific content. Students read about topics being studied in lab activities or concepts that were presented to them

in lecture to practice using disciplinary literacy tools. This provided opportunities to see and experience the science content they were learning and to read about it the way practicing scientists would. Because of these choices, a framework was demonstrated that other instructors could follow to incorporate disciplinary literacy instruction.

Leveled Reading Materials

In an effort to ensure students were still receiving all of the necessary content information as well as expand their abilities to engage with disciplinary literacy, primary research articles, anchor texts, and adapted primary literature were extremely helpful. Often, these texts were used to present a phenomenon that related to the topics being covered. For example, to introduce enzymes as unique proteins, students read a one-pager from the National Institute of Health on lactose intolerance. Incorporating these texts allowed students to engage with the discourse of science and apply the tools we had been learning (Wolsey & Faust, 2013). Over the course of the 12 weeks, the reading level of these texts was increased, and similar to the results by Kooman et al. (2015), students were able to more meaningfully engage in the sensemaking process of science.

As the study progressed, the level of adaptation decreased slightly, and articles became more difficult in terms of reading level. The students response to increasing the rigor of reading material was interesting. Students found the reading material easier as the study progressed, even though the rigor of the articles chosen actually increased. This was reinforced by the interim assessment results, when student scores showed an increase in self-efficacy on the assessment item addressing success on difficult reading materials for the course.

The use of primary research articles that had been leveled down to a high school reading level made the information more accessible to students, and they adapted to the style of writing

consistent with scientific literature. Student comfort increased, and as they demonstrated mastery of more skills, and conversely, the rigor of the articles continued to increase. This reinforced the importance of meeting students where they were linguistically from the start, allowing them to improve their ability to read like a scientist over time.

Mastery as a Metric

The consistent evaluation of data to inform research choices throughout the process enabled a comprehensive exploration of the research problem. Among the decisions made was using student mastery as a metric to determine whether to move forward to the next skill or to continue providing instruction on a specific tool. This metric was well-aligned with exploring increased student self-efficacy. Mastery often correlated with increased motivation to attempt a task and more positive body language when performing the task. Both behaviors demonstrated positive self-efficacy. Conversely, when students were missing mastery, they were slow to begin assignments, asked more clarifying questions before beginning, and tended to get frustrated with themselves more frequently. This second set of behaviors is consistent with negative self-efficacy. The correlation of these behaviors reinforced the decision to move forward once students reached an 80% mastery of each disciplinary literacy tool. This was, again, consistent with successful performance as outlined by Bandura (1977).

Additionally, the use of mastery as a metric allowed students time to get comfortable and experience success with each tool applied to primary scientific research. This was important because, as previously noted, scientific language is challenging to navigate, and students often find it difficult (Lemke, 1998a, 1998b; Unsworth, 2006; Yore et al., 2007). However, with the successful application of new literacy tools to the written language of science, student self-efficacy improved. Success with each tool laid the foundation for students to see their success

grow and their self-efficacy increase.

Transferability of Skills

The fact that student self-efficacy improved despite an increase in the rigor of content and work expectations provides supporting evidence that this approach is effective. That students could transfer the use of their skills to novel situations and unique situations accentuates the success of this research. Students applied the skills and tools they had learned in their classroom while completing work with other teachers in various learning environments.

Students applied some of the skills they had honed in class on district, state, and national level tests and other assessments. These other tasks were in no way identical to the assignments they had been given in class, yet they made a point to apply their literacy tools in new situations. This ability to apply the skills they learned to novel situations was beneficial both academically and psychologically, as it provided them with a way to tackle complex material in a familiar and comfortable manner. Clark et al. (2021) stated that the use of disciplinary literacy embedded in content instruction would allow students to use the tools they had learned in meaningful ways just as these students were able to apply them outside of their normal classroom activities.

Benefit to Special Populations

Although the research did not investigate the effect on special populations such as students with special needs. Thirty-four of the students within the group of participants are part of a special population. These include students who are multilingual learners, students with learning disabilities, and those with other specific learning needs. All 34 of these students have accommodations to make learning more accessible for them, but they still struggle to perform well on standardized assessments. Just as Pearce et al. (2020) found in their research, allowing students to actively engage in activities tied to content yielded better learning of academic

vocabulary. For example, a multilingual learner who has struggled to pass the English proficiency exams because of the speaking portion expressed that they were nervous about speaking up in class. In the past, they had limited opportunities to practice their academic language skills in a low-pressure setting. The opportunity to discuss disciplinary literacy tools with classmates allowed them the opportunity to practice what they needed and helped improve their confidence. This student now volunteers to discuss topics in front of the whole class and demonstrates work on the board.

The tools presented to students through instruction also offered a level of support to students in special populations. Highlighters allowed students struggling with dyslexia and attention deficit disorders to focus on specific areas of text. The use of annotations and Post-it notes provided students with a method to note definitions of complex or novel vocabulary and vernacular in a way that was easy to retrieve in the future. The positive impact of this intervention for those students correlated with increases in their self-efficacy. One student who had consistently struggled on language proficiency exams for verbal expression journaled that they were more comfortable taking their proficiency exam this year because of the practice with academic vocabulary through student focus groups and the reading done in class.

Once mastery had been achieved on a particular skill, students were not required to use it on future assignments. As more skills were acquired, they had a greater choice of tools and could use the tool that would benefit them the most for that situation. Students in special populations were essentially able to self-differentiate an assignment based on the tools they chose to use for a given task. These were tools that they had become comfortable with using, and had found ways to customize the application to meet their individual needs.

Limitations

The most notable limitation is one common to action research within classrooms: the results are not generalizable to the broader educational community (Anderson & Herr, 2015). Additionally, the sample of this study was a very narrow demographic entirely of honors students, and therefore not representative of the general population in American schools. All research was conducted in a single classroom, with instruction provided by a single teacher. It raises the question of whether the same processes would yield the same results in another classroom with a different teacher or demographic group.

This research was conducted over a 12-week period within a semester, and with normal school interruptions, such as fire drills, pep rallies, and mandated testing, it was challenging to maximize instructional time. In future cycles of this action research, allowing for more time and flexibility within an entire semester or academic school year would alleviate limitations presented by the time frame. This would also allow for more reflection on the part of the students to give more insight into the impacts of the instruction.

This research provides insight into only one cycle of the entire Action Research project. As the research progresses through future cycles, it will be beneficial to incorporate non-honors courses and involve additional teachers delivering instruction of the same tools in their classrooms. Increasing the participant pool will enhance the generalizability of the results and enable a more in-depth analysis of the factors contributing to change. Additionally, following this group of participants as they progress through the science courses and experience varied disciplinary literacy practices will provide insight into the transferability of the skills and their impact on self-efficacy in different settings.

Due to master scheduling constraints, this study was limited to only honors biology courses. This raises the question of whether the instruction of disciplinary literacy really only

improves the self-efficacy of students in honors-level courses. Future research that includes a broader range of coursework could provide insight into this aspect of the results. Additionally

The results of this research represent the impact of one teacher's instruction on disciplinary literacy strategies. As the research expands, it will be beneficial to include other teachers to see the impact of the student-teacher relationship, the teacher's instructional strategies, and the individuality the teacher brings to the classroom. By examining this, the results become more generalizable to a larger audience and a broader range of students.

Recommendations

Upon reflecting on the results of this research and my experience implementing disciplinary literacy in the classroom, several recommendations emerge. Among them are preparing teachers to implement the teaching of disciplinary literacy in the classroom, the need for campuses to vertically align instruction of disciplinary literacy across grade levels, and the importance of having students reflect upon their own self-efficacy and assess their level of comfort within the moment throughout the course.

Teacher Preparation Programs and Professional Development

The demonstrated difference in efficacy from this study highlights the importance of teaching students how to read scientific literature. As a teacher, the lead researcher noted that she had never received formal training in her university-based teacher preparation program on how to really tackle the intricacies of scientific disciplinary literacy. There had been no instruction as to how to teach these tools to her students. It was only after learning about disciplinary literacy in graduate education courses that she was able to apply this concept to her own classroom. If pre-service teachers were allowed to learn about disciplinary literacy and pedagogical methods for delivering lessons on disciplinary literacy, more students would have the opportunity to learn

how to navigate the unique literature in each of the various disciplines.

Vertical Alignment of Literacy Skills

Reading complex scientific texts and applying disciplinary literacy tools to make science more manageable is not something that should be limited to freshman-level courses. Incorporating vertical planning for students as they navigate their years of science in school could benefit them as they enter college by providing the experience of reading primary scientific literature and having a toolkit that they can apply to the unique nature of scientific writing.

As a result of this research, our campus will begin incorporating disciplinary literacy in sophomore-level science courses next year. Students will continue to utilize the tools they learned as freshmen in their sophomore honors chemistry courses, learn new applications of these tools, and expand their disciplinary literacy toolbox. Our campus will also incorporate disciplinary literacy instruction into all levels of freshman biology, with plans to expand it to all levels of chemistry the following year. The use of vertical alignment and the expansion of instruction will allow for the next cycle of Action Research to examine the impact of learning these tools on the self-efficacy of all students, not just our honor students.

Attending to the Self-Efficacy of Students

Utilizing reflections and self-efficacy assessments was incredibly helpful in the classroom. It provided a way to gauge student mindset after new content had been delivered and make informed decisions about moving forward. The information provided further insight into student learning. When students were being extra critical of their abilities, they also struggled to demonstrate mastery of a topic. When they improved, so did their attitudes toward their abilities in class.

Self-efficacy check-ins are now incorporated into our department's best practices to gauge student progress through the course. The correlation between achievement and self-efficacy supports the decision to be checking in with students to make sure that they are demonstrating a belief in their ability to succeed in class

Future Research

I found the results of the initial assessments on self-efficacy to be quite telling and raised many questions about why students with a long history of academic success would be so hard on themselves in terms of efficacy. I look forward to continuing to monitor the efficacy of these students as they move through school. I have already met with other honors and advanced teachers on my campus to brainstorm ways to continue working with this group and grow their efficacy. There is an opportunity for longitudinal research with this group as they move through high school, examining their self-efficacy and continuing to build their disciplinary literacy skills.

As a student who was tagged as gifted and talented in elementary school and carried that tag throughout my academic career, I found this particular study gave me opportunities to be very self-reflective. It was in this reflection and through discussion with my committee that the idea that the level of meta-cognition in students who are tagged Gifted and Talented (GT) could be higher than their on-level peers. So, it is possible that these students were simply more aware not only of how much they did not know themselves but also of the amount of knowledge there is to gain through scientific study, and the enormity of that thought influenced their views on personal success and self-efficacy.

One aspect of this research I would like to continue is the use of the data available to teachers. At North Texas High, “data-driven instruction” is a term heard on my campus at least

weekly. Yet, we limit the data we use to drive instructional choices to state or district-level assessments when there is so much more information available to us as teachers. Being singularly focused entirely on achievement data, too many opportunities to improve the learning experience for all students are missed. This process reinforces the idea that students come to classrooms with much more data than their test scores. Examining and tracking the changes in their self-efficacy data opens the door to much more information that informs instructional approaches and supports improved lesson delivery for educators.

As the study continued, they began to volunteer to share answers more often and chose to turn in verbal reflections of labs and daily work over a type written response. Another student who seemed to have never ending confidence was really struggling with self-efficacy. They had a score of a one on the preliminary assessment and over the course of research their score had grown to just over two. They still struggle with believing that they will be able to hand the difficult course work and reading material but they are improving. This knowledge allowed me the opportunity to work with this student one-on-one and help them see their own potential. Without student journals and reflections, I would have known none of this and my students benefitted by me knowing.

Future examinations with this group will include an analysis of their achievement and academic growth, using the disciplinary literacy instruction they have received and will continue to receive until the end of the spring term.

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Appendix A

Students Self-Assessments

The six items on the self-efficacy scale from Metacognition, Self-Efficacy and Learning processes in Science (dent -S) survey (Thomas et al., 2008)

Instructions. Please rate your agreement with the following statements on a scale of 1 to 5. Use a 1 to indicate that you strongly disagree with the statement, a 2 for disagree, 3 for neither disagree or agree, 4 for agree, and 5 for strongly agree.

1. I am confident of understanding the basic concepts taught in this course.
2. I believe I will get an excellent grade in this course.
3. I know I can master the skills being taught in this course.
4. I am confident I can do a good job on the assignments and tests in this science class.
5. I am confident of understanding the most complex material presented by the teacher in this course.
6. I know I can understand the most difficult materials presented in the readings of this course.

Appendix B

Pre- Post-Test

Students will take a pretest in which they are given a piece of primary scientific literacy and were asked to formulate a claim-evidence-reasoning statement of the research in the article. Students were given the same test as a post-test at the end of the study period. Highlighters, Post-it notes and blank paper were available but not required for student use. The following is the adapted literature students examined and the instructions they received.

BIOLOGY

Directions: Read the article below. Identify the **claim** you think researchers are trying to make. Use **evidence** in the article to support your claim. **Reason** with the evidence by using content understanding to explain why the evidence supports your claim.

INTRODUCTION Over the 200,000 years or so that modern humans have existed, human populations have adapted to a wide range of environments, including different foods. The availability of new energy-rich foods has resulted in different selection pressures affecting human evolution. For example, when some human populations started consuming milk as adults, the ability to digest lactose, the sugar in milk, provided a survival advantage to individuals with the trait. Over time, the lactose-tolerance trait increased in frequency in some human populations.

Another example of an evolutionarily important change in diet was the increased availability of starch-rich foods, beginning with the agricultural revolution about 10,000 years ago. Once starch-rich foods became common staples in the human diet, people who were able to effectively digest starch may have had a survival advantage.

Starch is a plant polysaccharide composed of many building blocks of glucose, which is a monosaccharide. Starch cannot be dissolved in water or in stomach acid, so an enzyme is needed to break it up. Starch digestion begins in the mouth with the enzyme amylase. Salivary amylase breaks the covalent bonds between glucose units in starch by adding a water molecule; this chemical reaction is called hydrolysis. The reaction produces maltose, a glucose-glucose disaccharide. Maltose is further broken down into glucose in the small intestine by the enzyme maltase.

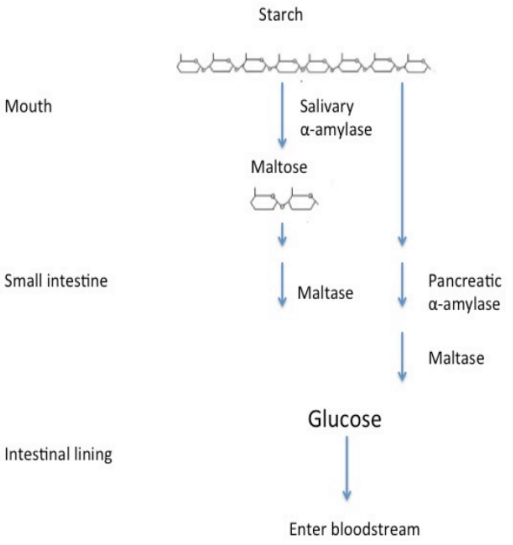


Figure 1. Steps in carbohydrate digestion. Carbohydrate digestion begins in the mouth, where salivary α-amylase attacks the α-glycosidic linkages in starch, the main carbohydrate ingested by humans, to produce maltose. The enzyme α-amylase is also produced in the pancreas (pancreatic α-amylase) and dispensed to the small intestine, where it converts any remaining starch molecules to maltose. Maltose is then cleaved into two glucose molecules by maltase. Monosaccharides, such as glucose, are absorbed through the wall of the small intestine into the bloodstream.

In humans, the AMY1 gene on chromosome 1 produces salivary amylase. Humans are diploid organisms, meaning that, except for the genes on the X and Y chromosomes, they have two copies of most genes—one copy inherited from each parent. However, genetic studies show that people can have anywhere from two to 15 diploid copies of the AMY1 gene on each chromosome 1, suggesting that the gene has been duplicated during human evolution. Why would this be?

Researcher George Perry and his colleagues hypothesized that as some groups of people started consuming more starch, individuals with more copies of the AMY1 gene would have had a survival advantage. It follows that people living in populations with starch-rich diets would have more copies of the AMY1 gene than people in populations that don't eat a lot of starch-rich foods (G. H. Perry et al., Nature Genet. 2007).

To test their hypothesis, Perry and colleagues analyzed DNA collected from two groups. The first group consisted of populations that have historically consumed a diet rich in protein and low in starch, such as hunter-gatherers living in tropical rainforests or near the Arctic Circle. The other group consisted of populations from agricultural societies and hunter-gatherers living in arid environments, which traditionally eat high-starch foods. The researchers measured the number of copies of the AMY1 gene in individuals from these different populations. In this activity, you will analyze some of the data collected by Perry and colleagues.

Table 2 shows some of the data Perry and colleagues collected on AMY1 gene copy numbers from different populations. The first group of individuals studied included 11 adult Americans of European descent, six Hadza (Tanzania), and eight Japanese, all of whom eat a high-starch diet. The second group of individuals studied included nine Biaka (Central African Republic), six Mbuti (Democratic Republic of Congo), eight Yakut (Siberia), and two Datog (Tanzania), all of whom eat a low-starch diet.

Table 2. *AMY1* Copy Number and Dietary Starch Levels

High-Starch Diet Profile		**Low-Starch Diet Profile**	
Population	**# of *AMY1* Gene Copies**	**Population**	**# of *AMY1* Gene Copies**
European-American	4	Biaka	8
European-American	8	Biaka	4
European-American	11	Biaka	2
European-American	6	Biaka	5
European-American	5	Biaka	4
European-American	6	Biaka	4
European-American	6	Biaka	6
European-American	15	Biaka	7
European-American	8	Biaka	4
European-American	8	Mbuti	4
European-American	7	Mbuti	7
Hadza	15	Mbuti	4
Hadza	5	Mbuti	4
Hadza	7	Mbuti	5
Hadza	6	Mbuti	4
Hadza	3	Yakut	9
Hadza	7	Yakut	4
Japanese	10	Yakut	5
Japanese	6	Yakut	5
Japanese	6	Yakut	9
Japanese	5	Yakut	10
Japanese	6	Yakut	8
Japanese	5	Yakut	5
Japanese	6	Datog	2
Japanese	7	Datog	8

Source: G. H. Perry et al., *Nature Genet.* 2007.

Appendix C

Letter to Parents

NORTH SIDE HIGH SCHOOL

2211 McKinley Ave
Fort Worth, TX 76179

Dear Students and Parents,

This year students in Ms. Tuff's biology class have the opportunity to participate in research on the impact of science literacy instruction on student self-efficacy. This study will happen during the fall semester and will not require students to do anything extra. The study will focus on evaluating activities that students are completing as part of in-class assignments to see how they impact student self-efficacy. Attached to this letter is a parent permission form that you fill out only if you DO NOT want your student to participate and a student assent form for students to sign if they would like to participate.

Ms. Tuff will be conducting this research and is available to discuss any questions or concerns you may have. She can be reached at jennifer.tuff@fwisd.org or 817-814-4000.

Thank you for the opportunity to work with your student to help improve instruction.

Jennifer Tuff
Biology Teacher
North Side High School

Appendix D

Parental Consent Form

Texas Christian University

PARENTAL PERMISSION TO CHILD'S PARTICIPATION IN RESEARCH

Title of Research: THE EFFECT OF DELIBERATE INSTRUCTION OF SCIENCE DISCIPLINARY LITERACY STRATEGIES ON SCIENCE SELF-EFFICACY OF SCIENCE TUDENTS

Principal Investigator: Dr. Molly Weinburgh

Co-investigators: Jennifer Tuff

Overview: We ask you to allow your child to participate in a research study. The following information is being presented to help you and your child decide whether or not your child should participate in a research study.

Study Details: This study is being conducted at North Side High School. The purpose of this study is to examine how direct instruction of disciplinary literacy tools in science effects student self-efficacy in science as part of regular instruction. Students will use various literacy tools to help improve their understanding of scientific texts. These assignments will be used to evaluate student progress of applying disciplinary literacy tools in science. Students will meet to discuss readings and over-arching topics they have studied in class. During these discussions, students will discuss whether study tools provided through instruction helped them in terms of self-efficacy with the material or classwork, how they understand or interpret new learning, and findings from labs. As outlined in the course syllabus, these discussions are recorded on student devices and submitted to provide the teacher with feedback on student progress. In an effort to meet the social and emotional needs of all students, teachers will have students complete self-assessments to gauge their own self-efficacy. Study participants will not be required to do any additional work but will allow the work, course discussions, and self-assessments to be evaluated for this research to identify the impact of the disciplinary literacy tools.

Participants: Your child is being asked to participate because they are a student in biology at North Side High School this year. If your child decides to be in this study, your child will be one of up to 90 participants in this research study at North Side High School.

Voluntary Participation: Your child's participation is voluntary. Your child does not have to participate and may stop participation at any time. Students who choose not to participate will still receive instruction and assistance with using these tools and how they apply to biology, and they will still be expected to complete all class assignments.

Confidentiality: Even if we publish the findings from this study, we will keep your study information private and confidential. Anyone with authority to look at your records must keep them confidential.

What is the purpose of the research? The purpose of this study is to examine how direct instruction of disciplinary literacy tools in science effect student self-efficacy in science.

What is my child's involvement for participating in this study?
Study participants will not be required to do any additional work or have any additional involvement outside of class. Student demographics, pre-posttest Claim-Evidence-Reasoning statement, pre-, interim-, and post-student self-assessments, student group reflections, and reflective journals for assignments on classwork will be evaluated for this research to identify the impact of the disciplinary literacy tools only.

Are there any alternatives, and can I withdraw?

There are no alternatives.

Your child does not have to participate in this research study. Your child will still take part in their scheduled biology class, and there is no penalty for not participating. Students who do not participate will still be expected to complete all assignments as part of their scheduled biology class.

Your child should only take part in this study if your child wants to volunteer. You nor your child should not feel that there is any pressure to take part in the study. Your child can withdraw at any time. It will not impact their course grade or status at North Side High School.

Students who wish to withdraw from participation must notify the researcher by email at Jennifer.tuff@tcu.edu that they no longer wish to continue. There is no penalty for withdrawal, but data already analyzed to inform the action research cannot be removed.

What are the risks to my child for participating in this study and how will they be minimized?

There are some risks your child might experience from being in this study. They may have some mild anxiety from participating in a group conversation. Participants are encouraged to let researchers know if they feel uncomfortable with any part of this research.

What are the benefits for participating in this study?

Although your child will not directly benefit from being in this study, others might benefit because of new information on helping students build efficacy in science courses.

Will I be compensated for participating in this study?

Your child will not receive a payment for participation.

What are the costs to me for my child to be a part of the study?

There will be no additional costs to you as a result of being in this study.

How will my child's confidentiality be protected?

Every effort will be made to limit the use and disclosure of your child's name to people who have a need to review this information. We cannot promise complete secrecy. Your child's records may be reviewed by authorized University personnel or other individuals who will be bound by the same provisions of confidentiality.

We may publish what we learn from this study. If we do, we will not include your child's name. We will not publish anything that would let people know who your child is.

What will happen to the information collected about me after the study is over?

We will keep your research data to use for future research or other purposes. These data will include classroom assignments transcriptions and recordings from student group reflections. Your child's name and other information that can directly identify you will be deleted from the research data collected as part of the project.

I may share your child's research data with other investigators without asking for your consent again, but it will not contain information that could directly identify your child.

Who should I contact if I have questions regarding the study?

You can contact Jennifer Tuff at jennifer.tuff@tcu.edu or 650-430-1307 or Dr. Molly Weinburgh at m.weinburgh@tcu.edu (817.257.6115) with any questions that you have about the study.

Who should I contact if I have concerns regarding my rights as a study participant?

Dr. Brie Diamond, Chair, TCU Institutional Review Board, (817) 257-6152, b.diamond@tcu.edu;
or
Dr. Floyd Wormley, Associate Provost of Research, research@tcu.edu

By signing this document, you agree to your child's participation in this study. Make sure you understand what the study is about before you sign. I/We will give you a copy of this document for your records. I/We will keep a copy with the study records. If you have any questions about the study after you sign this document, you can contact the study team using the information provided above.

*I understand what the study is about, and my questions so far have been answered. I **DO NOT** wish for my child to take part in this study.*

_____
Printed Subject Name (your child's name)

_____
Printed Parent/Legally Authorized Representative Name and Relationship to Subject

_____

Signature Date

Permission to be audio recorded.

I **DO NOT** agree to allow my child to be audio recorded.

_____

Signature Date

Consent to Use Data for Future Research

*I **DO NOT** agree that my child's information from this study may be shared with other researchers for future research studies that may be similar to this study or may be completely different. The information shared with other researchers will not include any information that can directly identify my child. Researchers will not contact me for additional permission to use this information.*

Yes _____ No _____

_____

Signature Date

Appendix E

Children's Assent Form

Texas Christian University

CHILDREN'S ASSENT TO PARTICIPATE IN RESEARCH (Ages 7-17)

Title of Research: THE EFFECT OF DELIBERATE INSTRUCTION OF SCIENCE DISCIPLINARY LITERACY STRATEGIES ON SCIENCE SELF-EFFICACY OF BIOLOGY STUDENTS

Principal Investigator: Dr. Molly Weinburgh

[Co-investigators:] Jennifer Tuff

Overview: You are invited to participate in a research study. In order to participate, you must be enrolled in biology at North Side High School and in class with Ms. Tuff. You will use various literacy tools to help improve your understanding of scientific texts. These assignments will be used to evaluate your progress of the application of disciplinary literacy tools in science and be used as study data. You will also meet to discuss readings and over-arching topics they have studied in class. During these discussions you will discuss if study tools provided through instruction did or did not help you in terms of self-efficacy with the material or classwork, how you understand or interpret new learning, and findings from labs. As outlined in the course syllabus, these discussions are recorded on student devices and submitted to provide the teacher with feedback on student progress. In an effort to meet the social and emotional needs of all students, teachers will have you complete self-assessments to gauge your own self-efficacy. Study participants will not be required to do any additional work. The work, course discussions, and self-assessments will be evaluated for this research to identify the impact of the disciplinary literacy tools.

What is the purpose of the research?

The purpose of this study is to examine how direct instruction of disciplinary literacy tools in science effect student self-efficacy in science.

What is my involvement for participating in this study?

Study participants (you) will not be required to do any additional work or have any additional involvement outside of class. Your demographic information, pre-posttest Claim-Evidence-Reasoning statement, pre-, interim-, and post-student self-assessments, student group reflections, and reflective journals for assignments on classwork will be evaluated for this research to identify the impact of the disciplinary literacy tools only.

What are the risks of participating in this study, and how will they be minimized?

There is a small risk that you may be anxious or nervous about your responses to classwork and reflection responses reviewed by researchers. All your responses will be kept confidential, and audio recordings will only be reviewed by researchers and not released publicly. Anything you write or say will not affect your grade or class standing. If at any time you are uncomfortable and would like to end your participation in the study, just notify the researcher.

Can I stop my participation?

You can say you want to stop at any time. You can stop even if your parents do not want you to stop. All students will still be required to complete class assignments. If you sign this paper, you are saying that you understand your participation. You also understand that you can ask questions and stop your participation at any time.

If you wish to withdraw from participation, you will need to email the researcher at Jennifer.tuff@tcu.edu and state that you no longer wish to participate. Again, there is no penalty for withdrawal, but data already analyzed to inform the action research cannot be removed.

Texas Christian University

*I understand what the study is about, and my questions so far have been answered. I **DO NOT** wish to take part in this study.*

_____ _____

Participant's Signature Date

_____ _____

Printed Name of the person obtaining consent Signature and Date

Consent to be audio recorded.

I **DO NOT** agree to be audio recorded. Yes _____ No _____

_____

Signature Date

Consent to Use Data for Future Research

*I **DO NOT** agree that my information from this study may be shared with other researchers for future research studies that may be similar to this study or may be completely different. The information shared with other researchers will not include any information that can directly identify you. Researchers will not contact me for additional permission to use this information.*

Yes _____ No _____

_____

Signature Date

Appendix F

Rubric for Grading Claim-Evidence-Reasoning Statements

	Exemplary	Proficient	Basic	Needs Improvement
Claim	The claim is clear and concise and directly addresses the research question. It is well-supported by the evidence presented in the journal article	The claim is clear and addresses the research question but may lack some specificity or connection to the evidence.	The claim is somewhat unclear or not entirely related to the research question. It may be vague or only partially supported by evidence.	The claim is unclear, vague, or does not address the research question. It lacks a clear connection to the evidence.
Evidence	The evidence is directly relevant to the claim, well-chosen, and accurately described. It includes specific data or findings from the research paper that strongly support the claim.	The evidence is relevant and generally well-described but may lack specificity or some detail in how it supports the claim.	The evidence is somewhat relevant but may be vague, insufficient, or not linked to the claim. There might be some inaccuracies in the description.	The evidence is largely irrelevant or incorrectly described. It does not effectively support the claim or is poorly connected.
Reasoning	The reasoning is logical, well-developed, and effectively explains how the evidence supports the claim. It provides clear and insightful connections between the claim and evidence.	The reasoning is generally logical and explains how the evidence supports the claim but may lack depth or clarity in some areas.	The reasoning is somewhat logical but may be incomplete or unclear in explaining the connection between the evidence and the claim.	The reasoning is illogical, incomplete, or fails to connect the evidence to the claim clearly.

Appendix G

Syllabus for Biology Course

Biology Syllabus **North Side High School 2024-2025**

Office Phone: 817/814-4000

Tutoring Times: By appointment with teacher

Course Description:

Welcome to Biology! This course emphasizes, through lab and field settings, scientific processes as they relate to living organisms. Concepts emphasized are cell structure and cell processes, which include transport, energy transformations, protein production, and cell reproduction. Above the cellular level, emphasis will be on hierarchy and interdependence of living systems, development of organisms, inheritance, evolution, speciation, taxonomy as it relates to speciation and evolution, plants, and ecology. Independent study is expected.

Instructional Philosophy:

Students will engage in a variety of challenging, real-world applications and assignments to demonstrate academic rigor and to apply science in everyday life. They will be held to high expectations regarding their quality of work and personal behavior. Laboratory technique and experimental design, which include data collection, interpretation, and manipulation, will be consistent components of this course. Students will often work in cooperative groups but will be expected to complete individual assignments. Students will be expected to utilize district issued resources and will complete computer-based assignments.

Course Standards:

Per the Texas Education Agency the course standards for biology encompass the following:

1. Biology. Students in Biology focus on patterns, processes, and relationships of living organisms through four main concepts: biological structures, functions, and processes; mechanisms of genetics; biological evolution; and interdependence within environmental systems. By the end of Grade 12, students are expected to gain sufficient knowledge of the scientific and engineering practices across the disciplines of science to make informed decisions using critical thinking and scientific problem solving.
2. Nature of science. Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable.
3. Scientific hypotheses and theories. Students are expected to know that:
    a. hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power that have been tested over a wide variety of conditions are incorporated into theories; and
    b. scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established and highly reliable explanations, but they may be subject to change as new areas of science and new technologies are developed.
4. Scientific inquiry. Scientific inquiry is the planned and deliberate investigation of the natural world using scientific and engineering practices. Scientific methods of investigation are descriptive, comparative, or experimental. The method chosen should be appropriate to the question being asked. Student learning for different types of investigations include descriptive investigations, which involve collecting data and recording observations without making comparisons; comparative investigations, which involve collecting data with variables that are manipulated to compare results; and experimental investigations, which involve processes similar to comparative investigations but in which a control is identified.
    a. Scientific practices. Students should be able to ask questions, plan and conduct investigations to answer questions, and explain phenomena using appropriate tools and models.
    b. Engineering practices. Students should be able to identify problems and design solutions using appropriate tools and models.

5. Science and social ethics. Scientific decision making is a way of answering questions about the natural world involving its own set of ethical standards about how the process of science should be carried out. Students should be able to distinguish between scientific decision-making methods (scientific methods) and ethical and social decisions that involve science (the application of scientific information).
6. Science consists of recurring themes and making connections between overarching concepts. Recurring themes include systems, models, and patterns. All systems have basic properties that can be described in space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested, while models allow for boundary specification and provide a tool for understanding the ideas presented. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment.

Labs:

Students are expected to complete all labs in a safe, appropriate manner. A safety contract signed by both student and parent is required, as well as a passing grade (81%) on a safety exam before the student will be allowed to participate in laboratory activities.

Daily Work/Bellringers/Homework:

Daily work will be embedded in all lessons. Students will be expected to complete these assignments in-class any work not completed during class is expected to be done as homework. These assignments will be graded for demonstrated understanding.

Reflective Collaboration:

On a bi-weekly basis students will work in groups to talk through a concept we have studied in class. From time to time these conversations may be recorded using district issued student devices and turned into their teacher. The purpose of these recordings is to provide teachers with feedback on student understanding and application of scientific concepts.

Tests & Assessments:

Tests and other assessments, such as projects and presentations, will be assigned approximately every 2 – 3 weeks.

Student self-assessments:

Students will complete self-assessments in class to provide teachers with feedback on student understanding, comfort and efficacy in class. We understand that student learning happens best when students are comfortable with the material they are learning and we want to gauge where students are so we best meet their academic and social emotional needs. Below is an example of a student self-assessment:

Please rate your agreement with the following statements on a scale of 1 to 5. Use a 1 to indicate that you strongly disagree with the statement, a 2 for disagree, 3 for neither disagree or agree, 4 for agree, and 5 for strongly agree.

7. I am confident of understanding the basic concepts taught in this course.
8. I believe I will get an excellent grade in this course.
9. I know I can master the skills being taught in this course.
10. I am confident I can do a good job on the assignments and tests in this science class.
11. I am confident of understanding the most complex material presented by the teacher in this course.
12. I know I can understand the most difficult materials presented in the readings of this course.

Assessment Plan (Grades):

All assignments are designed to show whether students have met the standards for the course. Any unit test, project, lab report, or homework assignment assessed as “poor quality” (70% or less) will be expected to be REDONE for higher credit up to an 81% during tutoring hours.

Approximate Distribution of points will be as follows:

Projects/Test	30%	Lab Reports	30%	Homework	5%
Daily Work**	30%	Reflections	5%		

** This will include your interactive notebook, notes, self-assessments, and participation in class.

Description of Grading and Quality Work

Grade	Scale	Description of work
A	90 – 100%	Above Average to Outstanding Progress
B	80 – 89%	Satisfactory to Above Average Progress
C	70 – 79%	Limited to Average Progress
F	Below 70%	Failing
I		Incomplete

Extra Help:

Extra help is available through all Biology teachers before, during, and after school. Because of occasional meetings, please let one of us know when you are coming. We are willing to work with individuals or small groups – sometimes working with a buddy helps you both understand the material better. Any student who does not maintain a grade above 81% is expected to attend tutoring sessions.

Late/Make-up Policy:

The student is responsible for making up any work missed due to absences or tardies. You will be given the same number of days to make up the missed work as the days you were absent. If work has already handed back students will be provided an alternate assignment to recover missed points.

Supplies:

Each student is expected to obtain and have each day:

- A writing utensil such as a pen or pencil
- notebook or lined paper
- School issued laptop

Plagiarism and cheating will not be tolerated. Plagiarism and other forms of academic dishonesty will result in no credit.

Contact Information:

Ms. Jennifer Tuff

Jennifer.tuff@fwisd.org

Ms. Keren Tran

Keren.tran@fwisd.org

Mr. Michael Legorreta

Michael.legorreta@fwisd.org

Please fill out this form acknowledging receipt of this syllabus:

Student Name_____

Student Signature _____

Parent Name_____

Parent contact information:

Phone number _____

Prefer call or text (Please circle one)

Email address _____

Prefer phone or email (Please circle one)

Parent Signature _____

Please list any questions or concerns regarding this class or syllabus:

_____
_____
_____

Appendix H

Protocol for Focus Group Discussions

A semi-structured question protocol will be used during Student Group Reflections. Below is a general outline of the questions students will answer during their initial reflection prior to starting disciplinary literacy learning. General conversation and questions from students may lead to probing questions intended to elaborate on given responses.

Question 1: Talk about your favorite classes. They don't have to be science but what are/were your favorite classes in school.

- Probing question. What do you like about it and why is it that it's your favorite?

Question 2: Ok now discuss your LEAST favorite classes. ANY class. Tell me why that one is/was your least favorite class(es). What about it did you just not like or why was it just not your favorite?

- Probing questions. Did you have fun? Did you like the material? Was it too easy or too hard? What sorts of things did you do that you did or did not like while you were in that class?

Question 3: When you are in class, what sorts of things help you learn?

- Probing questions. Some examples might be studying textbooks, reading about other people who are experts in their field, doing projects, taking notes, participating in a class discussion, or observing a class discussion.

Question 4: Think about the activity from the previous question- why do you think that activity helps you learn?

Question 5: What is the hardest type of learning activity for you?

- Probing questions. Can you tell me more or give me an example?

Question 6: How do you feel when something in school is hard, or you don't understand it?

Question 7: What is the hardest class you've ever taken and what made that class so hard?

Question 8: When you finished that class would you ever want to take that class again?

- Probing questions. Why or why not?

Question 9: Let's discuss science specifically. Did you know that you have to take four years of science in high school? How does that make you feel?

- Probing question. Tell me more.

Question 10: What do you think are the best parts about science classes?

Question 12: What do you think are the worst parts about science classes?

Question 13: What are the most and least challenging things about science?

*Probing suggestions could include labs, projects, tests, textbooks, vocabulary, daily work, journals, writing assignments, reading assignments…

Question 14: What challenges come to mind when you think about science? You may not have any, or you might have many, so feel free to share.

Follow up: What do you think contributes to your views on science challenges?

You said, "____" can you elaborate on that?

Question 15: When you must read something written by a scientist how does that make you feel?

Question 16: What does it mean to think like a scientist? Write like a scientist? Read like a scientist? Do you think you can do those things? Explain

Question 17: What do you hope to get out of your experience in biology this semester?

END of study discussion questions:

Q1: At the beginning of this semester you were asked how you felt about science class. Are your feelings the same or different now?

- Different: Can you please elaborate on that for me?
- Same: thank you for your honesty. Are you saying that you still think "_____" about science class?

Q2: When you think about challenges in science, how do you feel about them now? Think about what you thought at the beginning of the semester: "_____."

Q3: When you read something written by a scientist, how does that make you feel?

Q4: At the beginning of the semester, what was your favorite class and why? Do you think that these feelings of favoritism impact how you think you will do in a class?

Q5: How do you anticipate doing in biology the remainder of this school year?

Q6: At the beginning of the semester, you said that four years of science classes sounded like "___." Do you feel the same today? Can you tell me more about that?

Q7: How do you feel about writing assignments in science class today?

Q8: What do you think it means to think like a scientist? Write like a scientist? Read like a scientist? Do you think you can do those things now?

Appendix I

Reflective Journal Prompts:

Describe how the literacy strategy of highlighting to pair text and text features has helped you understand the information we read and evaluate in class. For example, does this help you to understand scientific writing? Does it make you more or less comfortable dealing with the class information? Now that you have this strategic tool, how do you feel about doing science?

Describe how the literacy strategy of annotating has helped you understand the information we read and evaluate in class. For example, does this help you to understand scientific writing? Does it make you more or less comfortable dealing with the class information? Now that you have this strategic tool, how do you feel about doing science?

Describe how the literacy strategy of using and designing graphic organizers has helped you understand the information we read and evaluate in class. For example, does this help you to understand scientific writing? Does it make you more or less comfortable dealing with the class information? Now that you have this strategic tool, how do you feel about doing science?

Describe how the literacy strategy of concept mapping has helped you understand the information we read and evaluate in class. For example, does this help you to understand scientific writing? Does it make you more or less comfortable dealing with the class information? Now that you have this strategic tool, how do you feel about doing science?

Appendix J

CITI Certification

Completion Date 09-Apr-2024
Expiration Date 09-Apr-2028
Record ID 61906896

This is to certify that:

JENNIFER TUFF

Not valid for renewal of certification through CME.

Has completed the following CITI Program course:

Human Subjects Research
(Curriculum Group)
Human Subjects Researcher (social-behavioral-educational)
(Course Learner Group)
2 - Refresher Course
(Stage)

Under requirements set by:

Texas Christian University

CITI
Collaborative Institutional Training Initiative

101 NE 3rd Avenue, Suite 320
Fort Lauderdale, FL 33301 US
www.citiprogram.org

Generated on 08-Mar-2025. Verify at www.citiprogram.org/verify/?w4ac3443e-f121-47eb-a8c9-2b6e887afd4d-61906896

Appendix K

Letter of Understanding

NORTH SIDE HIGH SCHOOL

2211 McKinley Ave
Fort Worth, TX 76164

To Whom It May Concern:

I am writing this letter in support of the IRB application submitted by Jennifer Tuff. I understand that this project will be an Action Research study conducted in Jennifer's classroom at North Side High School. I understand that Jennifer will be examining the work completed by her students as part the normal curriculum and lessons in biology to inform her research on student self-efficacy in science.

I fully support this research study occurring at our site. Please do not hesitate to contact me if there are any questions regarding our cooperation with this project.

Sincerely,

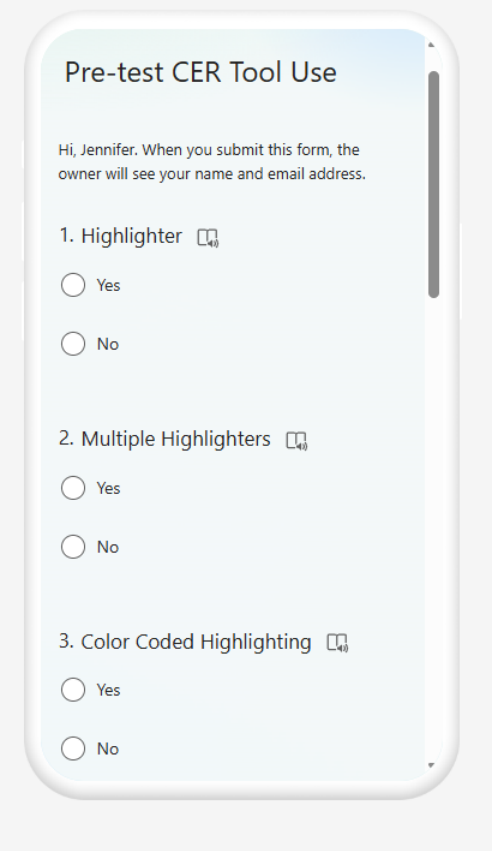
Antonio Martinez Jr. M.Ed.
Principal , North Side High School
Steer Pride, Maroon & White
Fort Worth Independent School District
PH – 817-814-4010
2211 Mckinley Avenue | Fort Worth TX. 76164
antonio.martinez@fwisc.org

Appendix L

Codebook for use of tools on pre- and post-test Claim Evidence Reasoning statements and screen capture of form used to input into Excel on Microsoft Forms.

Codebook for evaluating student tool usage on pre- and post-test CER

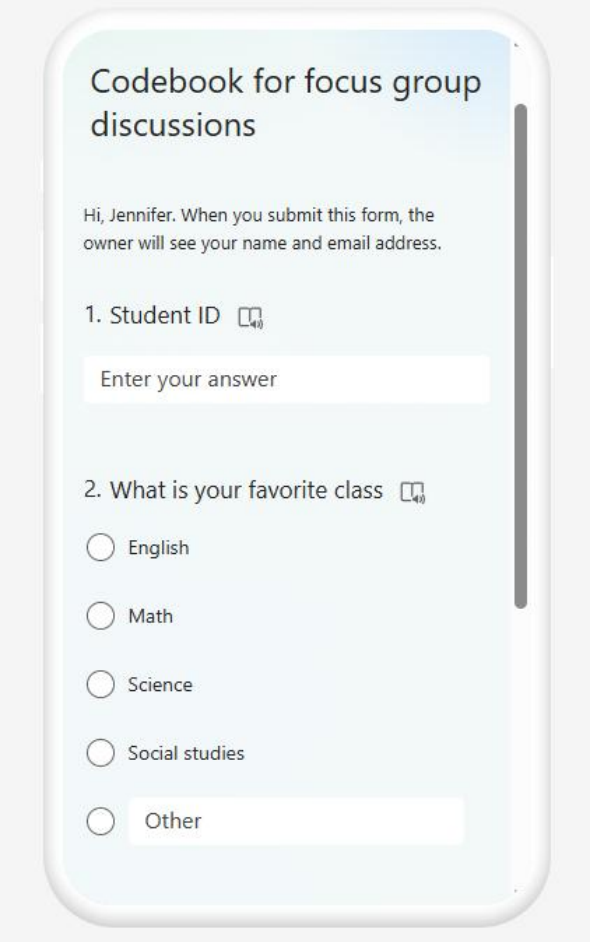
Tool	Used	Not Used
Highlighter?	Yes	No
Multiple Highlighters?	Yes	No
Color coded highlighting?	Yes	No
Annotations?	Yes	No
Post-it Notes?	Yes	No
Graphic Organizer (teacher created)	Yes	No
Graphic Organizer (student created)	Yes	No
Mind Map	Yes	No


Pre-test CER Tool Use
Hi, Jennifer. When you submit this form, the owner will see your name and email address.
1. Highlighter
Yes
No
2. Multiple Highlighters
Yes
No
3. Color Coded Highlighting
Yes
No

Appendix M

Codebook for Focus Group conversation responses

Question	Possible Responses	Additional codes
What is your favorite class?	English, Math, Science, Social Studies (history) other	Other: Art, music, foreign language, physical education
What is your least favorite class?	English, Math, Science, Social Studies (history) other	Other: Art, music, foreign language, physical education
Why is this your favorite?	Open response	
Why is this your least favorite?	Open response	
What kinds of things help you learn?	Labs, reading, research, writing, discussions, lectures, visuals	
What are the best parts of science?	Labs, reading, research	
What are the worst parts of science?	Labs, reading, research	


Codebook for focus group discussions
Hi, Jennifer. When you submit this form, the owner will see your name and email address.
1. Student ID
Enter your answer
2. What is your favorite class
English
Math
Science
Social studies
Other

Vita

Jennifer Tuff

Fort Worth, Texas

EDUCATION

Doctor of Philosophy in Science Education

Texas Christian University

Fort Worth, TX, 2025

Master of Education

Texas Christian University

Fort Worth, TX, 2019

Bachelor of Science in Kinesiology

Major: Sports Psychology and Coaching

California State University, Long Beach

Long Beach, CA 2005

PROFESSIONAL MEMBERSHIPS

National Science Teachers Association (NSTA)-(2009-Present)

Association for Science Teacher Education (ASTE)-(2023-Present)

School Science & Mathematics Association (SSMA)- (2023-Present)

PROFESSIONAL APPOINTMENTS

Department Chair North Side High School, Fort Worth Texas, (2021-Present)

New Teacher Mentor, North Side High School, Fort Worth, Texas (2019-Present)

Lead Content Teacher, Fort Worth ISD, Fort Worth, Texas (2018-2021)

Biology/AP Environmental Science Teacher, North Side High School, Fort Worth, Texas (2009-Present)