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Embedding Scientific Literacy In The Intermediate Elementary Classroom In Schools With High Underperforming Groups

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EMBEDDING SCIENTIFIC LITERACY IN THE INTERMEDIATE ELEMENTARY CLASSROOM IN SCHOOLS WITH HIGH UNDERPERFORMING GROUPS

by

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ABSTRACT

The achievement gap has been a widespread problem amongst minority groups, specifically African American students. The data reflects a continuous trend of underachievement caused by environmental factors at home and in school. As the state transitions to the 2019 Minnesota Science standards, teachers must learn to develop scientific literacy into the intermediate classroom and attempt to close the achievement gap amongst minority students. The capstone project uses the Sheltered Intervention Observation model, Marzano Framework, and *A Framework for K-12 Science Education* to answer the capstone question, *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?* The capstone project is a three to four week fifth grade life science curriculum that focuses on active learning, cooperative learning, and digital learning.

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CHAPTER ONE

Introduction

Background

My destiny was determined the moment I took my first breath of air and my ethnicity was recorded on my birth certificate. As a result of my skin color, I faced several challenges growing up and had no clear direction of my future. The teachers in the primary and secondary schools I attended, were unprepared to teach students from diverse backgrounds. I entered first grade significantly behind my peers and was pulled out of class for remediation to later be placed into an academically gifted program in the third grade that I struggled and later exited. There were three academically achieving groups in elementary school and I was unsure of which group I was a member. Furthermore, I observed more students of color in remediation and below level classes and more white students in advanced placement and honors classes starting from elementary school to the university level. In college, I found myself struggling on a backwards spiral in science lectures and labs. The labs were rigorous and the concepts were unapproachable. Consequently, I was not prepared to do college level science and struggled to find my educational identity. My background and initial orientation to an unconventional teaching program created a pathway for me to pursue teaching as a career.

Experience at the Charter School

The students were just dismissed after a few long and overtaxing days of MCA testing at the charter school. Students, teachers, and most importantly, the principal knew the results were available. Anxiety ran through the nerves of the teachers as they all walked to the student progress meeting to discuss academic achievement for Math, Reading, and Science. “Math was pretty good," the principal said smiling, "and so was Reading." Third and Fourth grade teachers sighed as if the cure of global warming had been found. Suddenly his eyes pierced Fifth grade teachers. "We need to improve Math for next year and Science was in the 20s," he mumbled, not looking the least bit surprised. This was not the first year student achievement was low in fifth grade science.

The next school year, fifth grade teachers met to discuss reasons Science scores were low. "I asked the principal if I could take a class on physics because I just do not feel confident in teaching that topic. I always wait until the end of the year to teach it. Let's try something new next year. Do you want to teach science and social studies?" Mr. Jones said.

I felt discouraged about teaching a subject teachers did not emphasize due to a higher emphasis placed on math and reading. However, seeing previous years' science scores, I was determined to find the root cause of this severe deficiency in knowledge. It was worse than vitamin D deficiency, but at least with vitamin D deficiency, you can take a daily vitamin to normalize the levels. Closing the achievement gap in science was more like finding the cure to cancer.

Rational

The experiences at a school in the Midwest with predominantly East African students and my own personal experiences growing up as a student of color encouraged me to explore the question: *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?* Students at high poverty schools were achieving significantly lower than students at low poverty schools. This data raised a concern across several school districts around the country, which caused further investigation of the underlying reasons for the deficiency. I want to propose a solution in the format of a curricular unit, so that educators could access research based strategies to improve science achievement in the intermediate classroom of disadvantaged groups.

This capstone presents chapters 1-4 in sequential order. In the first chapter, I discuss my journey to the capstone question, including my learning experiences in a district in the southeast and the intended audience for the final project. In this chapter, I also discuss the challenges and successes at the school where I am currently teaching upper elementary, and the reasons for choosing a science curricular unit for disadvantaged students.

Early Learning Experiences

In fourth grade, my teacher asked me what I wanted to be when I grew up. I was always seen as the *class pet* because I was acting in accordance with the middle class rules and expectations regarding how a successful elementary school girl should behave. During recess, I would volunteer to serve as an art helper. I actually preferred volunteering over going to recess. Art was one of my interests and reading was my weakness.

“I want to be a teacher,” I said nervously.

“Really? Don’t be a teacher. It is very hard because your students move on to the next grade. The students you have in your classroom become your real kids and a strong attachment forms between you and your students. Unless you are strong enough to allow hundreds of kids to enter your heart and then leave, you should do something else.”

Despite this advice, education was the career that I had always intended to pursue. However, I was encouraged to pursue a career in math or science as my math grades and standardized test scores were in the 90th percentile, but my reading scores were low. In middle school, I took a seventh grade science class. The science classroom had three rows of lab tables that were not utilized whatsoever. The students watched National Geographic videos and answered 100-question monotonous worksheets. I was far more concerned with getting the answer and copying it down than understanding the reasoning behind the phenomena.The teacher was lackadaisical concerning our education and failed to use researched based strategies to engage students. Science was boring and I associated it with meaningless worksheets that failed to boost my comprehension. I did not conduct one experiment or hands on observation during seventh grade.

In high school, I was placed in honors science courses because the students enrolled in honors math were concurrently enrolled in honors science. At this point, I failed to see the connection between literacy and science. My scores were mediocre, but I do remember the biology labs being engaging. The class dissected different organisms and recorded observations on a worksheet. The hands-on learning seemed to happen after direct teaching of the content. However, the teaching was strictly teacher elicited and the inquiry aspect of the lesson occurred following textbook prescripted lessons.

During my last year of high school, I took advanced honors physics and advanced placement calculus and English. I was not recommended to take advanced placement calculus or English because I performed poorly in the precalculus class. In addition, I was recommended for a lower level math class and my 90th percentile standardized math scores from elementary school were not factored into this decision. I went to my advisor to request placement in the advanced placement courses and she told me my legal guardian would need to sign the recommendation form. At this point, I realized my teachers had no clue to my potential as a student and wanted to confine me to average level work. My teachers did not see the whole picture and I did not feel that I could trust them as their motives were to keep be unchallenged. I passed the Advanced Placement calculus exam with the highest score possible and was only a point away from passing the English exam. I gave credit to my advanced calculus teacher for seeing my potential and preparing me for the test using a variety of teaching methods. She graded differently than other teachers and she made me feel like an important part of her classroom. Thus, I never wanted to miss a single class even for a field trip. My final grade in her class was determined by her professional judgement on my academic performance of the subject and not merely on a calculated grade derivative formula. She focused on building relationships with students and unconventional methods of teaching. As a response to her teaching style, I have dedicated my capstone to improving educational outcomes of disadvantaged students.

Later, I attended a world renowned engineering university in the southeast. My initial major was engineering, but after taking a course on psychology, I decided to change my major to psychology with a science focus. After changing my major, I transferred and earned a bachelors of science degree in psychology and a minor in neuroscience from a large accredited college in the midwest. Prior to graduating, I thought about my post graduate options and considered pursuing a medical degree in optometry, so I enrolled in a college level chemistry course and lab course. The course had an inquiry component that I was not prepared for and I felt like I was drowning. I did not know how to plan out and carry out investigations in my science notebook, define the problem, or develop and use models in the context of chemistry. These challenges ultimately caused me to withdraw from the course.

A few months later, I overheard from my peers that an alternative teaching program was searching for prospective teachers of color and disadvantaged applicants. The program placed recent college graduates into high poverty schools in cities that have a challenge finding teachers. I applied and was accepted immediately. Five months from my application date, I appeared in front of an upper elementary classroom and was labeled a teacher. While teaching, I took classes at night twice a week until I completed the teacher preparation program.

Being in this program meant that I was responsible for increasing achievement for disadvantaged students and working toward equitable education for all. I had no experience and was not considered highly qualified because I had obtained a community expert license through the teaching program. This experience made me wonder if I was the person these students really needed or if a highly qualified teacher with a masters degree and experience would do a better job.

Accepting a Challenge

Two years after teaching in the midwest, I came to the conclusion that I needed to take a year off and decide if I wanted to continue teaching. After exploring other professions and working as a substitute teacher in the southeast, I moved back to the midwest and returned to the original school. The principal offered me a teaching position in fifth grade, which made me slightly hesitant to accept. I knew the fifth grade math and science scores have been treacherous for the past several years. Additionally, the staff retention in the fifth grade was low. It seemed reasonable that the principal wanted to place me in this position because he was aware of my commitment to the school and my previous success in math achievement.

Overall, there were many challenges during my first year teaching fifth grade. The school had transitioned to a new lesson plan format that follows Marzano learning theory (Dean & Marzano, 2013). The teachers were required to create scales for each standard. The school had also purchased the latest Pearson science curriculum in anticipation of the new science standards. The new science curriculum supported the Next Generation Science Standards (NGSS). The lessons engaged students in science inquiry and supported literacy by targeting critical reading and writing skills (Pearson, 2019).

An Unplanned Plan

As a new teacher in fifth grade, I followed the seasoned teachers' suggestions and recommendations. I was responsible for planning the language arts lessons and was given the lesson plans from the previous year. During my second year in fifth grade, I planned the science lessons. Planning the language arts lessons gave me a guideline to how I intended to plan the science lessons as the format of the lesson plan was identical.

The Marzano Learning Theory was implemented in each lesson plan (Dean & Marzano, 2013). Teachers were expected to utilize the proficiency scales to plan instruction. For example, level 2.0 content often required direct instruction. Students became familiar with vocabulary terms, introductory concepts and foundational skills at this level. In addition, the teacher presented factual information related to the topic in the format of direct instruction. The 3.0 level of the proficiency scale had students perform an action such as asking students to perform exercises that enhance how well they understand a topic of process. The lessons from this level would have students examine similarities and differences between objects or categories and help students master the target learning goal. The level 4.0 required the students to apply their knowledge to real-world situations (Marzano, Yannoski, & Paynter, 2015). The Pearson Science Curriculum and the scales from the Marzano Learning Theory were used to plan strategic and engaging lessons in the format of 15-20 minutes of direct instruction and center work.

The next challenge that came knocking on my door was directed from the principal. He suggested interconnecting the language arts standards into science lesson plans. My world suddenly fell down on me as I had remembered despising reading. I also was concerned with the timeframe to cover the fifth grade science plans and also review third and fourth grade plans in preparation for standardized testing. I was not prepared to incorporate literacy in science and was unable to recognize the benefit. As I planned my lessons, I desperately searched for any language standard that I could tie in to science instruction just to satisfy my principal. The primary goal was covering the science standards and reviewing three grades of instruction. The standardized test scores increased significantly as a result of executing the interdisciplinary curricula plans designed using the Marzano learning theory and the new Pearson science curriculum. After testing was over, I read aloud science biographies and other nonfiction stories.

The Summer that Changed it All

Later, I enrolled in the 2019 Summer Mississippi River Institute and learned strategies to integrate literacy instruction in science. I also reviewed the Minnesota K-12 Academic Standards Committee's Recommended draft to the Commissioner. The 2019 Minnesota Academic standards (2019) stated that "the standards are grounded in the belief that all students can and should be scientifically literate" (p. 1). As I continued reading, I suddenly thought about the conversation I had with my principal about integrating language arts standards in science instruction. A plethora of questions entered my mind.

“What does it mean to be scientifically literate?” I questioned.

“Does an integrated approach to science and literacy increase achievement in both science and language arts?” I added.

I was curious to learn more about scientific literacy especially due to the new 2019 Minnesota Science Standards. I had planted a seed for scientific literacy at the Mississippi River Institute and internally knew this would benefit students, especially disadvantaged students. Moreover, the students were interested in scientific nonfiction and I wanted to incorporate science stories into the science curriculum. The charter school in Saint Paul had also changed sponsors and the new requirement for the sponsor was to integrate environmental education by selecting a system in the environment to focus on and improve. The 2019 Mississippi River Institute, revised Minnesota State Science Standards and the school’s sponsor had inspired me to create a curriculum to increase scientific literacy in disadvantaged students.

The Unit Curriculum

The unit curriculum I developed encomposses components of a series of lessons that allow disadvantaged groups to access current and future science standards. I have successfully implemented Marzano levels in my classroom for the past two years and have observed an increase in achievement in science. However, I have struggled to see the same achievement in language arts. Knowing my passion is science, I believe developing a fifth grade science curriculum will improve my literacy and science instruction. My students scored higher in informational text than literature last year and I believe the current curriculum is a skeleton that elementary teachers can build on to develop scientifically literate individuals. Ultimately, this science curriculum is for elementary teachers who serve in high poverty schools and for disadvantaged students. However, many of the practices can be used in schools nationwide. I hope that this capstone also serves intermediate level educators in the elementary classroom. I have been responsible for science achievement for the fifth grade for the past two years, and since the charter school in Saint Paul is planning to teach self-contained, I expected the capstone to provide a solution for the poor performance of disadvantaged students in science and literacy. The curriculum includes many of the frameworks that are currently used at the school, so adapting to the curriculum is necessary to continue the achievements that have been occurring at the school for the past few years.

Conclusion

My past experiences as a student and an educator have led me to explore: *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?* I also regularly reflect on my teaching performance and am observant of my strengths and weaknesses. The unit curriculum that was developed makes planning purposeful and brings the rigor and high expectations to students of color and other disadvantaged groups. The derivation of this unit curriculum has made me realize the significance of embedding scientific literacy in the classroom as a whole, and has made me wonder how I can successfully implement the research and best practices from the literature review to provide an example curriculum for elementary educators. In order to reach the goal of scientific literacy in disadvantaged students, the capstone gives educators a guide that includes an example unit plan with lesson plans, activities and assessments that uses the 2009 MN Science Standards.

Chapter Two provides a review of the literature in science achievement in disadvantaged groups. It illustrates the reasons behind poor performance in science and examines educational practices and interventions that have been effective in improving performance. Chapter Three will discuss the school, setting, and participants in detail. It also provides the standards and related benchmarks, frameworks, and methodology for developing the curricular unit. Chapter four reflects on the project limitations, successes and future implications of the unit curriculum.

CHAPTER TWO

Literature Review

Introduction

Educators in Minnesota are well aware of the inequality that exists between disadvantaged students and students of privilege in science achievement (Minnesota Assessment Results Reading, Mathematics, and Science, 2017). In order to develop the appropriate methods as an educator to increase scientific achievement in low performing students, the question, *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups,* will be analyzed and investigated.

This literature review illustrates the poor performance in science of disadvantaged students, and communicates reasons cited in evidence-based research reports linked to poor educational attainment. It focuses on the double effect of scientific illiteracy and being classified as *disadvantaged*. Then, it defines scientific literacy and explains the importance of being scientifically literate, associating improvement in scientific literacy positively correlating with elementary science achievement.

This literature review also proposes multiple variables to increase science achievement and synthesize current research around the variables. It examines the educational practices and interventions that have been effective in improving performance in elementary science. This section erodes reform science pedagogy by discussing inquiry, language development, culturally responsive teaching, and other considerations.

Poor Academic Performance/Underachievement in Disadvantaged Students

In order to answer the research question concerning increasing scientific literacy in disadvantaged students, it is important to examine the Science MCA results of students of color, specifically black students. On the Science Minnesota Comprehensive Assessments, Black/African American students in grades five, eight, and high school scored a mean score of 22.25% from 2014-2017. This group was the lowest performing ethnic group and had one-third the proficiency rate of their white counterparts. American Indian/Alaska Native and Hispanic/Latino students were performing only marginally better than Black/African American students (2017 Minnesota Assessment Results Reading, Mathematics, and Science, 2017).

In Minnesota, Black/African American students have statistically performed significantly lower than White students. However, some disadvantaged groups have managed to *beat the odds*. MCA Science proficiency rates at the charter school for Black/African American students were similar to the states' proficiency rates from 2014-2015. However, scores increased 23 percentage points in 2016 and continued to improve (Minnesota Department of Education, 2018). Overall, minority students in Minnesota have continued to perform significantly lower in science. The next section will discuss the causes of underachievement in disadvantaged students.

Causes for Underachievement

Banerjee (2016) stated that educational disadvantage starts in the womb. The factors that contribute to performance deprivation are lower socio-economic status, ethnic minority status, speaking English as a second language, and immigration status. These factors lead to two common features: 1. Lack of positive attitude towards school and learning and 2. Less supportive environment.

Family Factors. The first cause of underachievement and the reason for implementing a unit curriculum is lower socioeconomic status. High levels of aggression and violent behavior are related to lower socioeconomic status. Aggressive behavior becomes disruptive in the classroom, causing a reduction of learning in students of lower socioeconomic status (Banerjee, 2016, p. 5). In schools of lower socioeconomic status, educators should consider how the effects of lower socioeconomic status such as high levels of aggression can impact the learning environment. For planning purposes, teachers should consider the learning environment by providing an environment conducive to learning that is student centered and interacting with students in a way that is facilitating scientific literacy and connecting to students in a personal way.

Another reason for poor achievement in school is authoritative parenting. Families living in lower socioeconomic neighborhoods are known to employ fewer early childhood educational practices causing lower academic achievement in the early years as well as later in life. Additionally, mothers that are illiterate are more likely to raise underachieving children despite belonging to the same socioeconomic class. Payne (2003) found, “even though the income of the individual may rise significantly, many patterns of thought, social interaction, cognitive strategies, and so on remain with the individual” (p. 1). In terms of achievement, the student’s social class in which they were raised seems to correlate with poor academic achievement. Consequently, the student must be taught middle-class “hidden rules” to remediate achievement (Payne, 2003, p. 1).

The socioeconomic status and the parenting style of the disadvantaged students have profound effects on the readiness of the individual to access scientific literacy. Knowing this, provides more reasoning to construct ways students can feel empowered in their learning. Student centered learning is at the centerpoint to engaging students and through student interaction with the content, peers, and facilitator. Students can then begin to formulate their own understanding of science as long as educators reinforce these types of positive interactions. The next cause of underachievement that will be discussed is student mobility and immigration status.

Student Mobility/Immigration Status. An additional cause of underachievement that several families in Minnesota face is student mobility. Immigrant families are faced with many challenges including basic survival, returning overseas to care for family, and transitioning into American society. Banerjee (2016) stated, "A higher proportion of immigrant and working-class pupils in a school is associated with lower levels of math achievement in both immigrant and native Belgian pupils" (p. 6). The child's education does not take priority. Theoretically, immigration status may result in underachievement.

Similarly, student mobility is another cause of underperformance (Grift & Houtveen, 2010). Students leave school because of relocation, retention, or by choice. Student populations are more unstable in urban cities than in rural areas. This instability influences disadvantaged students' academic achievement (Grift & Houtveen, 2010, p. 385). Some students change schools in the middle of the year and are not given a science placement or skills assessment in order for educators to remediate instruction before the school year ends. These students are at a disadvantage compared to students who have remained at the same school for longer periods of time, as schools vary in the order standards are taught.

Student mobility and immigration status proves to be a challenge to many educators. The intentional design of a curriculum unit that meets the needs of disadvantaged students can be difficult, especially if the lessons are consecutive and depend on prior knowledge to be successful at accessing the content. The curriculum unit may provide the support for disadvantaged students who have minimal prior knowledge by providing background knowledge in each of the lessons linked with science and literacy objectives. The next section addresses the environmental factors that perpetuate underachievement.

Environmental Support at School. Several environmental factors feed into disadvantaged students continuing to underachieve. A shortage of learning time, poor-quality instruction, inadequate assessments for measuring student achievement, and a non stimulating educational climate are ineffective and are found in underperforming schools (Grift & Houtveen, 2010, p. 386). Teachers' negative expectations and weak instructional quality are also correlated with lower test scores. Teachers not giving clear instructions and not involving students during lessons affect achievement adversely (Grift & Houtveen, 2010, p. 391). Additionally, poor classroom management results in lower achievement because students are not engaged and directions are not clear and concise. On the other hand, positive teacher expectations, support, and motivation have a positive effect on the student achievement of disadvantaged students (Banerjee, 2016, p.10).

Teaching staff in underperforming schools insufficiently use standardized test data to improve the quality of instruction. Disadvantaged students are also assessed on standards intended for students in lower grade levels, alluding to a reasonable false achievement (Grift & Houtveen, 2010, pg. 392). As a result, the students are advanced to the next grade level, debilitating achievement even further. In addition, students are being differentiated into ability groups and follow an individual learning trajectory, working in isolation at their own level (Grift & Houtveen, 2010, p. 394). Another instructional method schools implement is the pull-out program, where poorly performing students are taken out of the general education classroom. Disadvantaged students are not benefiting from this instructional strategy because they are introduced to a problem and taught problem solving methods (Grift & Houtveen, 2010, p. 394). Unfortunately, before they can grasp onto the learning process in class, they are pulled out and expected to work on another solution, perpetuating academic loss. The pull-out and ability grouping instructional methods keeps disadvantaged students underperforming unless they are given the encouragement to work on grade level and the opportunity to work in a heterogenous classroom. In the upcoming section, the relationship between neuropsychological factors and achievement will be discussed.

Neuropsychological Factors. Neuropsychological factors and poor health in general have been linked to decreased achievement. Neuropsychological variables account for a 30 percent variance in mathematics scores among 5th grade participants according to study by (Waber et al., 2006). These students obtained fourth grade scores on state standards based testing. Malnourishment is the main cause for neuropsychological changes. Disadvantaged students are less likely to consume a regular breakfast and regular intake of fruits and vegetables compared to affluent ones (Banerjee, 2016, p. 11) Teachers who want successful students must encourage healthy eating habits by motivating students to consume a regular breakfast, lunch and dinner. Afterall, teachers are generally more concerned with the well-being of their students.

Educators understand that without the proper nourishment, students cannot maximize their own learning.

In conclusion, several factors correlate with underachievement in minority students. For this reason, answering the question, *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups,* can seemingly pose a challenge to educators. The next section discusses scientific literacy and how educators approach scientific literacy in the classroom.

Scientific Literacy

The United States of America has an overtly high rate of scientific illiteracy. More than 90 percent of Americans are scientifically illiterate (Maienschein, 1998). If 90% of Americans are scientifically illiterate, the percentage of disadvantaged students that lack scientific literacy may statistically be even higher. The National Science Education Standards states, “scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity.” (*National Science*, 1996, p. 22)

A scientifically literate person can ask, find, or determine answers to questions and are critical thinkers (*National Science*, 1996). The person can describe, explain, and predict natural phenomena. In order to be scientifically literate, a person must be able to comprehend science articles in the popular press and validate conclusions. A scientifically literate person can also identify core science issues underlying national, state and local decisions, choose and defend their position based on evidence derived. Lastly, a person can pose and evaluate arguments based on evidence and draw conclusions on the arguments (*National Science*, 1996).

Consequently, promoting scientific literacy requires a new way of teaching. Educators are not prepared to teach scientific literacy because learning science is an active process that requires physical and mental activity (*National Science*, 1996). Teachers also must stop relying on teacher centered instruction because learning science is something students do, not something that is done to them. Students learn more by interacting with scientific phenomena than observing it through teacher centered instruction (Kali & Linn, 2008).

Generally, educators have struggled on implementing scientific literacy into classroom practice and student learning (Smith, Loughran, Berry & Dimitrakopoulos, 2012). This is mainly due to the two different visions of scientific literacy. Vision I is science centered and focused on science subject matter. Vision II is student centered, with the goal of producing scientifically literate citizens who think critically and creatively about the natural world (Maienschein, 1998, Smith et al., 2012).

Smith et al. (2012) stated that "the way a teacher thinks about and understands scientific literacy personalizes the meaning in terms of practice" (p. 148). Teachers were involved in a project titled *Valuing and Promoting Scientific Literacy in Science Teaching and Learning* which focused on professional discussion about scientific literacy and examined alternative approaches to enhance scientific literacy for students. The results of the study were that teachers had revised their thinking about scientific literacy to mean discussion, argument, communication, investigation and questioning their surroundings . They discovered science with the students and have changed their way of thinking by not telling students the answers all of the time (Smith et al., 2012). Therefore, discussions surrounding scientific literacy in disadvantaged schools would be a necessity to increase science achievement and to answer the question: *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?*

Equity in Science

According to the National Science Education Standards, science is for all students (1996, p. 20). The principal for equity and excellence that the *Standards* had intended since 1996 is not demonstrated in 2019 for disadvantaged students. The *Standards* encourage the idea that these students should be given an equal opportunity to learn science and should be highly encouraged to pursue science (*National Science*, 1996). Vi-Nhuan Le (2006) found that classrooms that had a greater access to science materials had significantly higher test scores, supporting the claim that "students who have greater access to equipment and resources have more opportunities to participate in activities that foster scientific understanding" (p. 69).

The National Science Education standards described outcomes that students are expected to achieve, but failed to explain or provide a plan for disadvantaged students to produce these outcomes. In addition, teachers were unprepared to teach due to the lack of science materials and curriculum to make science equitable to all students. Schools should be partnering with organizations such as 3M that provide free science resources to educators or applying for federal or state grants, so disadvantaged students have an equitable education.

Knowledge, Understanding, and Inquiry

The first step to increasing scientific literacy is to understand how scientific knowledge is acquired. Scientific knowledge can be acquired in a variety of ways. Facts, principles, theories, laws, concepts, and models develop one's scientific knowledge. Understanding science is developed over time and requires an individual to integrate a complex structure of many types of knowledge, including the relationships between the ideas of science and reasons for these relationships. Ways to use the ideas to explain and predict other current and future natural phenomena (*National Science*, 1996).

Gaining access to scientific inquiry will increase scientific literacy. The *Standards* refer to inquiry as the diverse ways in which scientists study the natural world and formulate explanations based on their work (*National Science*, 1996). Students gain access to inquiry by developing their knowledge and understanding of scientific ideas by being exposed to different activities. Inquiry involves making observations; posing questions; examining sources and reviewing what is already known in light of experimental evidence; planning investigations; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating results (*National Science*, 1996). Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations (*National Science*, 1996).

The *Standards* recommended teachers to use different strategies to develop knowledge and inquiry. Not one single experience or method can achieve proficiency in inquiry. Scientific inquiry is a collaborative activity in which students should work in groups to pursue answers to questions (Douglas, 2006, p. 5). Teachers should use different strategies on a consistent basis with different materials to increase inquiry and should have students acquire a science notebook, used for the purposes of recording and organizing data, observations, sketches, thoughts and arising questions (Douglas, 2006, p. 5). Inquiry and knowledge are 50% of scientific literacy, so it is imperative to understand how teachers can successfully implement scientific inquiry, knowledge, and understanding into the classroom.

Science Inquiry and Literacy

As mentioned previously, science inquiry is a collaborative activity and involves students working together in groups discussing, planning, and conducting investigations. Students also take turns in sharing responsibilities for talking, reading, writing, and other roles (Douglas, 2006, p. 12). Douglas explained that literacy is embedded in science inquiry because communication in the form or talking, reading, writing, uses language. Students also communicate using pictorial and numerical representations. Literacy is developed when students talk and write about their questions, explanations, plans, data, conclusions and their reasons and judgements about relationships between evidence and explanations (Douglas, 2006, p. 12). Teachers can encourage the development of students' abilities to do science inquiry by providing plenty of opportunities and guidance for students to develop excellent oral and written skills (Douglas, 2006, p. 13).

The ways in which students encounter science can either allow an appropriate assimilation of knowledge or create immense difficulty. Students must encounter knowledge through first hand engagement in relevant scientific inquiries, rather than encountering knowledge through print. According to Douglas (2006), an example of appropriate assimilation of knowledge is:

> In investigations of motion, they learn meanings of descriptors (e.g., *displacement*) and operational meaning of words that express ratios and other kinds of relationships. The concept of acceleration, for example, is derived from concepts of velocity and time, and velocity in turn related to displacement and time. Acquisition or the concept of velocity, therefore, is a precursor for a clear scientific understanding of acceleration, and an

> introduction of these terms to account for observed behaviors of phenomena during scientific inquiry enables students to grasp their special meanings. (p. 13)

The way that science phenomenon assimilates can help answer the capstone question, *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?* Teachers should consider introducing students to precursors of phenomena, so students can grasp the concept fully. One of the ways the unit curriculum could address this is through background knowledge and investigations of the science concepts.

Developing and Supporting Student Science Talk

It is suggested that when students are given opportunities to talk about their ideas, including responding and challenging the ideas with peers and teachers, higher level thinking is enhanced (Douglas, 2006). Facilitating fruitful discussions in science requires a special skill set from the teacher (Douglas, 2006). Similar strategies from researched-based literacy and mathematics programs are used in science discussions. In addition, teaching science talk requires attention to the science content and standards; nature of a classroom culture of science inquiry; purpose of discussion; guiding of discussion; and record keeping of ideas and information (Douglas, 2006).

Many elementary teachers who teach science may think providing a hands-on exploration of materials is sufficient to create a culture of science inquiry in the classroom (Douglas, 2006). However, science talk or science discussions are arguably as important because of the rigorous scientific reasoning taking place. Teachers should include a variation of the following norms to promote a culture of achievement in discussions: 1. Discussion takes place 2. Ideas and experiences are shared 3. All thoughtful and interesting ideas are valued 4. Scientific reasoning is expected 5. Debate and argument are a part of the learning process (Douglas, 2006).

Orchestrating a fruitful discussion requires the teacher to proceed through three basic stages (Douglas, 2006). During the opening stage, teachers established the purpose of the discussion and reviewed appropriate norms and expectations. During the middle stage, rich discussion and teacher and student questioning and commenting took place. Productive questioning opened up student thinking and students made connections, observations, and predictions. Wright and Nuthall (1970) conducted research on teachers' reactions to students' responses and found that redirecting the question to another student was significantly related to achievement. This may be due to redirecting causes students to open up their thinking and make connections between thoughts during the discussion. The closing stage, depending on the purpose of the discussion, may review ideas and/or state a conclusion (Douglas, 2006). According to Wright and Nuthall (1970), discussing content relevant information during final stages of the discussion was positively related to achievement. The next section discusses parallel reading and science comprehension strategies that increase science achievement.

Comprehension Strategies

The increase in science achievement of underrepresented groups was the result of an inquiry program during the late 1990s (Douglas, 2006). Moreover, scores in reading and writing increased significantly in comparison to students who were not in the inquiry program. One of the main factors that contributed to the rise in achievement was the use of science notebooks by every student, in every classroom, everyday. The science notebook focused on making meaning from investigations and prioritizing evidence when responding to questions (Douglas, 2006).

The underlying thinking skills or strategies in science and reading are the same. The thinking strategies in the science notebooks began with an engaging scenario or an anticipatory set, a mental set that caused students to focus on what they have learned (Douglas, 2006). This thinking strategy is comprehension strategies relating new to known schema and creating sensory images. The first thinking strategies in science and reading were related because both are connecting prior knowledge to what will be learned. The second thinking strategy in the science notebook was the focus question. This thinking strategy is related to questioning in reading. The focus question and questioning strategies in science and reading are related because both strategies involve students' creating questions to focus their attention and guide their thinking. Posing critical questions helps readers reach proficiency in understanding the text or scenario. The third thinking skill in the science book was hypothesis/prediction. Likewise, inferring was the reading strategy that parallels hypothesis/prediction. When students inferred, they created a meaning that was personal to them based on evidence from the text and relevant prior knowledge (Douglas, 2006). Similarly, when students hypothesized or made a prediction, they created a plausible explanation for a given set or data or observations and predicted the possible outcomes for the investigation. The thinking strategies hypothesis/prediction and inferring were connected because both focused on creating meaning based on what was known from prior knowledge and observations. The fourth thinking strategy was claims and evidence and was related to determining importance. Students made a statement based on observations in the experiment or in a reading text, students filtered information and organized their thinking to make decisions about what is important to enhance their overall comprehension of the text (Douglas, 2006). The fifth strategy, making meaning conference, and its correlated reading strategy, monitoring for meaning, is nearly identical in thought process. Teachers used this strategy to provide feedback and students monitor, evaluate, and make revisions to their work until they are ready to move on to the final strategy. Conclusions is the sixth thinking strategy. Conclusions are comparable to reading strategy synthesizing. Students summarized the information by bringing together their background knowledge, evolving ideas, and information from other relevant texts in an original way (Douglas, 2006).

In summary, science notebooking and the use of parallel reading and science thinking strategies increased achievement in underrepresented groups. Including science notebooks in the materials section and embedding parallel reading and science thinking strategies in paramount to answer the question, *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?* The next section continues the discussion using the science notebook. However, this section discusses how writing can be embedded in the science notebook.

Increasing Achievement through Writing

Science notebooks have been shown to increase achievement in science through the use of paralleling comprehension strategies with the science notebook strategies. Research has found that developing students' thoughts through their writing deepens their understanding in science as well (Douglas, 2006). Lee et al. (2005) found that when writing was used to supplement science concepts, student achievement in literacy and science was enhanced.

Students can develop their writing in science notebooks, field notebooks documenting observations, journal articles citing research and new questions and lab reports that outline specific procedures. Most teachers limit the use of scientific writing to recording data and writing conclusions. However, writing opportunities are infinite and depend on the student's learning of science as well as the teacher's knowledge of the using science experience in writing contexts (Douglas, 2006). It is known that science journaling is an important factor of success and should be made as part of the unit curriculum. Teachers who want more successful students with less behavior problems must ensure journaling helps students reflect on their learning by having them think about where they are on a scale and write about how they feel emotionally and motivationally (Hanrahan, 1999, pg. 705)

Students engaged in a variety of nonfiction writing modes when writing in their science notebook. The descriptive mode, explanatory mode, procedural mode, recount mode and persuasive mode are examples of writing types used in science (Douglas, 2006). The writing types parallel benchmark 5.6.2.2 in the Minnesota Writing Standards (Minnesota Academic Standards, 2010). Students wrote descriptions based on their observations in descriptive writing. For example, a student may use their five senses to create a vivid description of a deteriorating plant. The explanatory mode of writing was used to explain how something works or why something happens (Douglas, 2006). For example, fifth graders studying landforms wrote about why they think the river flowed the way it did based on their evidence they gathered during the investigation (Douglas, 2006). The procedural mode was used when students were developing plans to carry out an investigation. The students' plan needed to be clear, concise and specific (Douglas, 2006). The information was presented logically and is a sequence of events. The first step is the goal of the investigation. For example, if the goal of the investigation was to build a system to contain and clean up an oil spill, the remaining steps would include a series of steps to achieve the goal ("Mississippi Rivers Institute", 2017). The final step would be to evaluate whether or not the procedure was successful (Douglas, 2006). The recount mode, told in chronological order, the events that took place during the science investigation (Douglas, 2006). Lastly, the persuasive mode was used to convince the audience that the students' claims were reasonable. The supporting evidence in the form of qualitative and quantitative data was used to back up their assertions. Fifth graders studying buoyancy can write a persuasive text to convince their audience that every object in the water has a tendency to either sink or float, based on evidence from their observations during the Neutral Buoyancy Challenge ("Mississippi River Institute", 2017). The structure of persuasive writing began with an opening statement of position followed by supporting details and concluding with a summary of the position (Douglas, 2006). All modes of writing contained specific ways of using language that should be explicitly taught in language arts. Teachers could prepare students for success in writing about science by scaffolding the learning with modeling, guided practice, and independence (Douglas, 2006).

Science Stories

A student centered method that enhances scientific literacy is a scientific story (Gucluer & Kesercioglu, 2015). Baumann and Bergeron (1993) developed Six elements of a story that asks the questions who; what; when; what is the problem; what happened and what was the solution. The stories have taken apart misconceptions and created curiosity and interest in science (Gucluer & Kesercioglu, 2015). The science stories also helped students visualize difficult concepts . Visualizations have supported science inquiry learning because they make complex processes visible (Kali & Linn, 2008). Science stories could potentially benefit disadvantaged groups, especially those who resist learning science because they believed they would not be able to learn. The scientific narration was fun and educational (Gucluer & Kesercioglu, 2015).

The stories included knowledge about various topics and used culturally relevant heros as well as world renowned literature, such as the Three Musketeers. The characters solved problems using science. For example, if the students were learning about the absorption of light, the students read stories *Into the Light* and *Electronboy and the Vizier*. Students scored higher on the achievement test after being exposed to science stories. Most importantly, students gained confidence in understanding science when it was taught using the scientific narration method (Gucluer & Kesercioglu, 2015).

Overall, reading comprehension strategies, writing, and science stories are purposeful ways scientific literacy can be embedded into the intermediate classroom. These strategies, methods and engagement techniques are used to answer the research question, *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?* The next section discusses an instructional unit that was successful in increasing science achievement.

Reforming Science Achievement

An intervention comprising instructional units, teacher workshops, and teacher classroom practices with their students was found to be effective in reforming achievement of disadvantaged groups. The instructional unit contained student booklets, science supplies and teachers' guides. Each lesson in the teachers' guide included specific correlations with state standards in science, language arts and mathematics, a glossary of science vocabulary, and transparencies of pictures, drawings, tables, graphs, and charts. The lesson also included key elements of science, English language and literacy, and home language and culture. Suggestions about how to set up and implement hands-on activities are included in the teacher's guide. Extensive background knowledge and detailed explanations for the answers to the questions in the science booklet are also included. They offer supplementary items such as extension activities, assessment activities, homework assignments, and field trips (Lee. et al., 2005).

The student booklets were designed with a progression moving towards opened-ended student-initiated exploration. Therefore, the beginning units were structured with more teacher explicit instruction. The units in the student booklets progressively became more challenging in terms of science concepts and the level of inquiry. Included at the end of each lesson is an explanation of the investigation. The units also featured common misconceptions and potential learning challenges (Lee et al., 2005).

Student booklets used specific comprehension questions about inquiry activities, strategies to increase comprehension at the end of each lesson and a variety of language functions (e.g., drawing conclusions, explaining, reporting). The teachers' guide provided suggestions for promoting literacy by engaging students in whole group, small group or individual reading on science material. The guides promoted literacy by including comprehension passages and writing prompts, causing students to engage in science topics even further. Students were expected to write summaries of their science experiments for homework. Lastly, the teachers' guide offered strategies to build the background knowledge of culturally and linguistically diverse learners (Lee et al., 2005). Including pertinent learning materials with reading, writing and science is key to answer the question: *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?*

Teacher Related Variables Related to Science Achievement

Professional development related to science inquiry and incorporating literacy into science instruction was one variable related to increasing science achievement. Teachers attended four workshops during the course of the school year to familiarize themselves on science content and inquiry practices (Lee et al., 2005). The workshops also covered how to incorporate English language and literacy development as well as students' home languages and cultures into science instruction. Teachers engaged in active learning by comparing and contrasting the teaching and learning environments among the six schools. The first workshop focused on inquiry. During the workshop, teachers applied their new acquired knowledge by working in teams, focusing on ways to incorporate literacy activities and ESOL strategies in science instruction. Lesson activities were student centered and focused on inquiry and open ended responses (Lee et al., 2005). During the third workshop, teachers worked on lessons in the instructional units and considered how to implement culturally responsive teaching ideas into the science lessons. For example, teachers wanted to engage students in cooperative teamwork as well as encourage students to work individually and independently during the time (Lee et al., 2005).

Other variables linked to science achievement were having a master's degree, teacher experience and confidence in science knowledge (Le, 2006). Ferguson and Ladd (1996) and Goldhaber and Brewer (2000) had consistent findings regarding the positive correlation between science achievement and masters degree and science specific undergrad degree. Accessibility to materials was also significantly associated with test scores (Le, 2006).

Educators play an active role closing the achievement gap. Cooperative teamwork and inquiry focused instruction are embedded in the curriculum unit. These student centered approaches aid in answering the question: *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?*

Nurture thru Nature

An unconventional intervention that sought to improve academic performance was Nurture thru Nature (Camasso & Jagannathan, 2018). The purpose of the program was for students to increase their science knowledge and understanding of the natural work by applying language arts and mathematics knowledge to scientific process skills such as creating hypotheses and answering questions. The program also encouraged students to participate in the creation of outdoor projects including, but not limited to, organic gardens, bird feeding stations, and caterpillar gardens. The program used a rubric to maximize the learning experience through a four stage sequential process 1. Interests, 2. Subject matter, 3. Real world application, 4. Classroom instruction (Camasso & Jagannathan, 2018). The results stated that the program had a significant impact on science and language arts achievement for disadvantaged students (Camasso & Jagannathan, 2018).

Summary

Disadvantaged students have failed to meet learning outcomes for decades. The backgrounds of these students including socioeconomic status, environmental support, neuropsychological factors, and mobility status have impacted students ability to access scientific literacy and pose challenges to teachers planning curriculum. Educators can face these challenges by integrating the literacy strategies into a curriculum unit that promotes scientific literacy.

The next chapter explores the methods used to develop the unit curriculum to answer the research question, *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?* The following chapter explains the context of the school and the methods used to develop a science curriculum that increases scientific literacy.

CHAPTER THREE

Project Description

Introduction

The purpose of this chapter is to describe the process used for developing the fifth grade science unit curriculum for marginalized groups. This chapter also explains the context of the school that the curriculum was used for, including the demographics of the students and teachers. The demographic information was included for the purpose of analyzing the connection between the curriculum and the participants. The curriculum was developed to examine the question: *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?*

This chapter discusses the methods used to develop a science curriculum that increases scientific literacy. The curriculum focused on active learning, cooperative learning, and digital learning and was aligned to the Life Science strand of the Grade 5 Minnesota Science standards. The curriculum was designed using *A Framework for K-12 Science Education* and the Sheltered Instruction Observation Protocol (SIOP) Model. This chapter also addresses the intended audience for the curriculum and the main purpose of developing scientifically literate individuals in disadvantaged groups.

Setting

The school is a charter public school that serves students in grades kindergarten through twelfth grade in Saint Paul, Minnesota. This school serves 99.8% Black or African American students and 0.2% Asian American students (Minnesota Report Card, 2018). The 2019 enrollment of all students was 612. The school had enrolled 67 or 10.9% English learners. This school was considered a high poverty school because more than 90% of students received free or reduced price meals. There were no homeless students reported at the school (Minnesota Report Card, 2018).

The number of experienced educators at the school were less than other high poverty schools statewide. Of the educators at the school, 66.67% were experienced compared to 79.49% of educators at high-poverty schools statewide. Low poverty schools had 88.96% of experienced staff, a significantly higher percentage. Similarly, this school had a lower percentage of licensed educators in the subject areas of the courses being taught. The school had 80.65% of courses taught by licensed educators compared to 85.37% of courses taught by licensed educators in high-poverty schools statewide. Low-poverty schools had 95.30% of courses taught by licensed educators. The school had 26.67% of educators with advanced degrees compared to 47.92% in other high-poverty schools and 64.49% of low-poverty schools statewide. A persistent gap of high-quality educators existed between this school and lower poverty schools in the state of Minnesota ("Minnesota Report Card," 2018).

The school purchased Pearson Interactive Science Program in 2016 in preparation for the new science standards. Teachers were trained during the professional development week by a licensed Pearson curriculum expert. Teachers were expected to use the Pearson Interactive Science Program as the core curriculum when designing lessons to align with the Minnesota State Standards. In 2013, the school purchased the Creative *Learning Systems Smart Lab* program for grades third, fourth and fifth. The program is an engaging program that develops STEM and digital media programs for elementary, middle and high school ("Creative Learning Systems," 2019). Grade level classrooms attended the labs for two week intervals and rotated with other grade levels. Each grade level classroom attended the *Creative Learning Systems Smart Lab* four days a week and were allotted 50 minutes per day during the two week intervals. Teachers were expected to teach using cooperative learning, active learning, digital learning and to discuss learning outcomes in the form of a daily reflection. Students' learning was assessed in the form of an online science notebook or powerpoint presentation.

In previous years, teachers worked in isolation causing significant differences in achievement among classrooms within the same grade levels. In 2017, educators were trained to operate in a professional learning community (PLC). The goal of the training was to improve the school by improving the skills and knowledge of educators through collaborative study and educational attainment and achievement of students through stronger leadership and teaching ("The Glossary of Education Reform," 2014). The PLC training led third and fifth grade teachers to engage in a new instructional approach, departmentalized instruction. The three fifth grade teachers decided to divide instruction among themselves. One teacher would teach math, reading or science and social studies to all students enrolled in grade five. Fifth grade teachers presented the departmentalized instructional plan to the principal for approval and implementation began during the 2017-2018 school year.

Rationale

The curricular unit was designed to address the question: *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups? The* learning gaps in science education faced by students represented in disadvantaged groups, specifically students of color, needed to be addressed in the form of a unit curriculum. Disadvantaged groups have achieved statistically significantly lower than white students in math, reading and science, so this unit was developed to engage teachers and poor performing students in rigorous instruction using proven instructional strategies. This curricular unit served as a guide for elementary teachers working at high poverty schools in Minnesota and was intended for the implementation and utilization towards other elementary science standards (Appendix A).

The curricular unit was designed to be implemented in 60-90 minute time intervals and in a variety of settings including the *Creative Learning Systems Smart Lab*, general education classroom and outdoors. The unit overview was aligned to the Grade 5 Science Minnesota State Standards and benchmarks. The standards and benchmarks were differentiated into Marzano Taxonomy which included the four levels of difficulty. The lessons for the unit were created with the Marzano Taxonomy levels in mind and each lesson was designed using the SIOP Interactive Design template and Science and Engineering practices (SEPs). The lessons stated the science and literacy lesson objectives, crosscutting concept, lesson background including misconceptions, interactive activities, group configurations/composition, key academic language, and ideas for academic interactions. The lesson also included the teacher and student materials. It clearly stated the motivation, presentation, practice/application, and review/assessment ("SIOP," n.d). The presentation section of the lesson plan was designed for student talk and this is where teachers developed and supported students' science talk. The practice/application section is where students engaged in inquiry and teachers focused on using the Science and Engineering Practices (SEPs). The review/assessment section was student centered and groups assessed themselves and their peers. This section is also where the writing modes were utilized to assess and extend individual student learning. Formative and summative assessments were included in the last section of the lesson plan. The curricular unit has the overall intention of developing scientifically literate individuals in disadvantaged groups by allowing access to knowledge, understanding of scientific concepts and processes required to make informed decisions about the world (National Research Council, 2012).

Minnesota Standards

The curricular unit focused on the life science strand of the Grade 5 Science Minnesota State Standards. The two standards that were used to design the curricular unit were Standards 5.4.1.1, and 5.4.4.1.

Life Science Standards

Standard 5.4.1.1 Living things are diverse with many different characteristics that enable them to grow, reproduce and survive.

The standard included the following benchmark:

5.4.1.1.1 Structures & Survival

Describe how plant and animal structures and their functions provide an advantage for survival in a given natural system.

For example: Compare the physical characteristics of plants or animals from widely different environments, such as desert versus tropical, and explore how each has adapted to its environment.

Standard 5.4.2.1 Natural systems have many parts that interact to maintain the living system.

The standard included the following benchmarks:

5.4.2.1.1 Relations in Living Systems

Describe a natural system in Minnesota, such as a wetland, prairie or garden, in terms of the relationships among its living and nonliving parts, as well as inputs and outputs.

For example: Design and construct a habitat for a living organism that meets its need for food, air and water.

5.4.2.1.2 Changes in Natural Systems

Explain what would happen to a system such as a wetland, prairie or garden if one of its parts were changed.

For example: Investigate how road salt runoff affects plants, insects and other parts of an ecosystem.

Another example: Investigate how an invasive species changes an ecosystem.

Standard 5.4.4.1 Humans change environments in ways that can be either beneficial or harmful to themselves and other organisms.

The standard included the following benchmark:

5.4.4.1.1 Humans & Natural Systems

Give examples of beneficial and harmful human interaction with natural systems.

For example: Recreation, pollution, or wildlife management. ("Minnesota Academic Standards," 2009).

A Framework for K-12 Science Education

The framework that was used to complete the unit was *A Framework for K-12 Science Education* and it was developed by the National Academies press. A science specialist from the Minnesota Department of Education recommended teachers to start using the newly developed Science and Engineering Practices (SEPs) with the 2009 standards. Therefore, the curricular unit utilized the eight Science and Engineering Practices SEPs. These practices were considered to be essential elements of a science curriculum and were not necessarily used as a linear sequence (National Research Council, 2012).

1. Asking Questions and Defining Problems
2. Developing and Using Models
3. Planning and Carrying Out Investigations
4. Analyzing and Interpreting Data
5. Using Mathematics and Computational Thinking
6. Constructing Explanations and Designing Solutions
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating, and Communicating Information (p. 3)

The framework prioritizes the notion that all students should have equal opportunities to learn and that students should personally identify with science, expressing a personal interest in the learning of science. The curricular unit used proponents of the framework by encouraging a nontraditional classroom where students used informal or native language and familiar modes of interaction (National Research Council, 2012).

Pearson Interactive Science Program SIOP Model

The curriculum unit was developed using the Sheltered Instruction Observation Protocol (SIOP) Model. This model is a proven framework for teaching both academic content and language skills in ways that are more effective for English Learners ("Pearson K-12 Learning," 2019). English Language Learners accounted for 10.9 % of students at the school and since ELL students have had deficiency in achievement across subject areas, the Sheltered Instruction

Observation Protocol (SIOP) model was used in conjunction with *A Framework for K-12 Science Education* developed by the National Academies.

The SIOP model had eight components and 30 features that have been shown to improve student achievement. The model also had the flexibility to include several of the instructional interventions and techniques from Chapter two because it ensures that research-supported combinations of features are present in every lesson. The eight components included lesson preparation, building background, comprehensible input, strategies, interaction, practice and application, lesson delivery and review and assessment (Echevarria, Richards-Tutor, Canges & Francis, 2011).

Timeline

The timeline for this capstone is two school years. The development of the research question and literature review was completed between June and August 2019. The curriculum unit was developed and a reflection was completed by the beginning of August 2021. The lesson plans for the life science strand of the Grade 5 Science Minnesota State Standards were developed using the Sheltered Instruction Observation Protocol (SIOP). Next, the resources including student activities and handouts, teacher guides, and assessments were drafted. Then, the content review provided feedback to the unit curriculum and another revision to the lesson plans and resources occurred shortly thereafter.

A formative assessment has not been developed yet. According to the Minnesota Department of Education (2021), MDE will continue to engage in test specification and development to prepare for the MCAs in spring of 2025 and 2026.

The capstone was completed and presented in August 2021. The curriculum unit can be used as early as August 2021, since educators are expected to start embedding the Science and Engineering Practices (SEPs) with the current 2009 MN state standards.

The curriculum unit is designed to be taught in 8- 50 minute blocks over the span of 4 weeks. Science will be alternated with social studies and will be taught two times a week with assessments on Fridays. When classes are in the Science, Technology, Engineering, Arts and Mathematics (STEAM) lab, they will have science everyday. In this case, the unit curriculum the completion time would vary from 3 ½ weeks to 5 weeks. The curriculum unit is an example unit for educators and more units are expected to be developed for the other grade 5 science strands.

Assessment

The effectiveness of this project will be assessed by a curriculum survey (see Appendix C). As teachers are lesson planning the life science unit, they will refer to the curriculum and assess the curriculum using the survey. Teachers can also assess the effectiveness of the curriculum after teaching the curriculum to their students. Teachers will rate the degree to which they agree or disagree with the statements. The project success depends on the data collected from the survey. Prior to implementing the curriculum, teachers can assess the current science curriculum using the survey in Appendix C. After implementing the curriculum and literacy strategies, teachers can assess the capstone project curriculum and compare the responses from both curriculums to answer the question: *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?*

Summary

This chapter addressed a meaningful instructional curriculum that will be developed to answer the research question: *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?*, of which the components of the curriculum have failed to be delivered to high poverty schools serving students of color in Minnesota. The setting, rationale and the two frameworks, *A Framework for K-12 Science Education* and the Sheltered Instruction Observation Protocol (SIOP) Model, were discussed to explain how the curricular unit was developed. The implementation of the curricular unit occurred during a transition of the 2009 Minnesota K-12 Science Education Standards to the 2019 Minnesota K-12 Science Education Standards and was designed to be evaluated and revised to meet the needs of individuals in disadvantaged groups in various regions of the nation. Chapter four includes a reflection of the curriculum development process, limitations and future implications to the profession.

CHAPTER FOUR

Critical Reflection

Chapter Overview

In the beginning chapters of the capstone project, I discussed the literature review, project design and personal connections to the research question: *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?* Chapter one included a sequential personal narrative and professional rationale, as well as the definition for scientific literacy. Chapter two contained a detailed literature review about the statistics of disadvantaged students, causes for underachievement, and interdisciplinary strategies significantly impacting achievement. In chapter three, the project description in the context of the school and the rationale were developed. The Marzano Taxonomy levels as well as the SIOP Interactive Design template and Science and Engineering practices were used to engage students in inquiry and provide access to scientific literacy from the basic levels of the Marzano Taxonomy to the higher order thinking levels. In addition, chapter three discussed *A Framework for K-12 Science Education* and the newly developed Science and Engineering Practices (SEPs) with the 2009 standards.

Next, in Chapter four, I reflect on the whole project and include my expected and unexpected learnings. Then, I revisit the literature review and connect important key information to the capstone project. Lastly, I provide possible implications and limitations of the project, followed by the benefits to the profession.

Purpose of the Project and Major Learnings

The purpose of my project was to provide a curriculum educators could use to embed scientific literacy in the intermediate classroom for underachieving students, specifically students of color in Minnesota. The data is clear in showing the achievement gap in Minnesota between students of color and students of privilege. For decades, students have been promoted to the next grade level with a lack of proficiency in not only science, but reading and math. Minimal curriculum development in the area of science has been developed to engage communities of color. This curriculum serves as an attempt to narrow the significant gap in science and provides all schools in Minnesota a curriculum unit that aids in transitioning schools with high underachieving groups to the 2019 MN Science Standards.

The curricular unit uses the Life Science strand of the Grade 5 Minnesota Science standards to develop lessons using the Sheltered Instruction Observation Protocol (SIOP) and Marzano Framework. While developing my project, I learned that it takes intentional planning of each part of the frameworks to deliver the learning outcomes necessary to close the achievement gap. I also learned that literacy must be embedded into each of the subjects, not only science and that the roll of a teacher is not to lecture and deliver the majority of the knowledge, but rather to create an environment conducive to student centered learning

The project also helped me reassess how I was teaching science and critically think about how I can develop and integrate strategies from the frameworks and alternative strategies to enhance scientific literacy such as discussion, argument, communication, investigation, and questioning using the lessons and standards that I previously taught. *What cross cutting concept does this standard address? What language objectives can I incorporate into the lesson? What background knowledge is necessary for the teacher and students to know to be successful at* *accessing the standard? Where can I set aside time for formal and informal discussion? How can I create an environment where students engage with each other through questioning their surroundings? How can I allow students to communicate their learnings? What settings are necessary for students to fully engage and investigate scientific phenomena? What materials are needed for students to properly gather, analyze and interpret data?* These questions were the initial questions that guided the lessons in the unit curriculum.

Another major learning from the development of this project is the importance of first hand engagement in scientific inquiry. Douglas (2006) explained that literacy is developed when students talk and write about their questions, explanations, plans, data, conclusions and their reasons and judgements about relationships between evidence and explanations (Douglas, 2006, p. 12). Learning how literacy develops impacted the development of the curriculum. The curriculum unit included appropriate times for students to talk and write about their questions, explanations, data and conclusions. Specifically in lessons 1-8, students had direct exposure to science investigations. I intentionally sought hands-on investigations and created handouts that caused students to talk and collaborate with their group. They interacted with the vocabulary in their center activity using a nearpod in lesson 1 and 2 and interacted with the nouns and verbs of the vocabulary in lessons 5 and 6 using Student Handout - 7 Plastic Codes. Incorporating these strategies was a major learning in the development of the curriculum unit and made me realize the benefit of having students engage firsthand in comparison to encountering science concepts in print. Next, the literature review will be revisited.

Revisiting the Literature Review and Newfound Understandings

Reexamining the literature review caused me to focus on the causes of underachievement and think about the purpose of developing the curricular unit in the first place. There are several notable reasons for underachieving students, with some being controllable and others not within our control. One thing we as educators can control is the school environment and the way that we teach our students. Therefore, I will be focusing on these two topics and explaining how these topics helped develop the unit.

Several environmental factors such as a shortage of learning time, poor-quality instruction and inadequate assessments for measuring students' achievement are found in schools with underperforming groups (Grift & Houtveen, 2010, p. 386). These factors contribute to low test scores. The findings of Grift and Houtveen were the driving force behind developing the unit curriculum (date). After this realization, I sought to select the frameworks I would use that integrated key strategies for improving learning outcomes of underperforming students. I wanted to ensure the frameworks focused on high quality instruction and rigorous assessments. The charter school was already implementing the Marzano Framework and using the Pearson Realize curriculum, so I decided to use the Marzano Framework in the curriculum unit. I also did some formal research on the Framework that Pearson uses and discovered the Sheltered Instruction Observation model (SIOP). I chose this model because this model supports diverse learners and was proven to move learners toward academic excellence.

As I was writing this curriculum, I analyzed each component of the Sheltered Instruction Observation Model and considered ways to implement proven science literacy strategies. I also thought about how I could incorporate the Marzano Framework into the curriculum unit. I decided to use the self assessment from the Marzano levels as a way for students to individualize their learning. Students can identify their learning level and ways to meet or exceed the learning targets.

Developing the Lessons

As I formulated a template for the lesson plans in the curriculum unit, I used the Sheltered Instruction Observation Model and components of the literature review that highlighted an increase in achievement of disadvantaged groups.

The first part of the Sheltered Instruction Observation Model is called Background knowledge. According to Douglas (2006), connecting prior knowledge to what will be learned is the first strategy that was used in an inquiry program during the late 1990s. Scores in reading and writing increased significantly in comparison to students who were not in the program. Therefore, it seemed necessary to use the first strategy as the background knowledge section of the curriculum unit.

The second part of the Sheltered Instruction Observation Model is called the Cross Cutting concept. This part was incorporated into the curriculum unit because *A Framework for K-12 Science Education* considered the cross cutting concepts to be essential elements in a science curriculum. The cross cutting concepts are used to understand scientific knowledge and are used to predict other current and future natural phenomena (*National Science, 1996*). If students acquire science knowledge through these concepts, I knew it was important to include the cross cutting concept into each lesson and to make sure the activities students were doing were linked to the cross cutting concept. For example, students would create models of adaptations and models of human interactions within the natural system.

The third part of the Sheltered Instruction Observation Model is called the Motivation. This part of the curriculum unit was formulated because the second strategy is related to students' creating questions to focus their attention and guide their thinking. Critical questions are also posed to students to engage them in understanding the goal of learning. In the Motivation section of the curricular unit, students are asked critical questions and students discuss their responses.

The Practice/Application part of the lesson correlates to the fifth strategy, making meaning conference. Teachers and monitoring students and providing feedback during the Practice/Application. Lastly, the Review/Assessment part of the lesson is comparable to the sixth strategy, conclusions. Students are summarizing their new acquired learning in their own words.

As depicted in this review of the literature, I used the three frameworks and proven strategies to increase scientific literacy as a means of creating a curricular unit for disadvantaged students. The next section addresses the limitations of the capstone project.

Limitations of the Project

Overall, there were certain limitations that either hindered the outcomes or made it difficult to assess the effectiveness of the capstone project. The project requires ample time to perform teaching and learning in the STEAM lab. However, classes receive two weeks per quarter in the STEAM lab and spend the majority of the time in the first quarter learning how to navigate the SMART lab programs, access folders, and follow directions from the facilitator and teacher. To make the project more effective, the 50 minute blocks should be increased and classes should attend the STEAM lab more frequently, so the capstone project could be implemented and evaluated appropriately.

Another limitation of the capstone project is the use of the 2009 standards, rather than the updated 2019 standards.The project uses the 2009 standards, so the capstone project will be effective only until 2023. Although the teaching strategies and learning model will be the same, the project needs to be updated to include the new standards. The project uses the 2009 science standards because schools are familiar with the standards and structuring a unit with familiar content provides more time for educators to curriculum plan within the school setting. However, this is a limitation for students because they will not be learning the standards that will be accessed on the MCA in 2023-2024 (MDE, 2020).

An additional limitation of the capstone project is the Pearson or Savvas Curriculum does not fully align with the 2009 standards. Therefore, outside resources were needed to plan the capstone project. Additionally, there is a high turnover rate in the charter school, so it is difficult to assess the effectiveness of the project relating to teacher retention.

Finally, administration in the charter school prioritizes math and reading over science. So, the importance of the capstone project in the specific school setting is a limitation. Similarly, the priority in disadvantaged schools is in professional development in math and reading. Thus, professional development in science is generally not offered in the school setting, leaving educators searching elsewhere to receive professional development, which can be costly and/or time consuming. The next section discusses the successes of the project.

Project Successes

There are several observable successes to the capstone project. Some interrelated components of the SIOP model, including lesson preparation, building background, interaction, practice/application, lesson delivery, review, and assessment were already being implemented in the unit plans at the charter school. Another project success was connecting the similarities and differences in the Marzano Instructional Framework, SIOP Model, and *A Framework for K-12 Science Education*. The frameworks included a vocabulary connection using nouns and verbs of the science learning target, as well as a guide to reviewing and assessing learning. Educators are able to overlap frameworks and combine components of each framework to deliver better unit plans and lessons.

A reduction of behavior issues is another success of the capstone project. Students are less reliant on the teacher to deliver instruction and learn primarily in the science centers. The teacher works with students to deliver instruction, clarify misunderstanding, and reinforce student thinking. Meaningful discussion also occurred during the motivation step of the SIOP model. Students were held accountable by completing science center work assignments on schoology and were given the opportunity to continue discussion with peers during science centers. They were also self reflecting in the STEAM lab a few times a week or in the classroom by circling and identifying with the Marzano level. The next section will address implications of the project.

Implications of the Project

When I reflect on my capstone question, *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?* I am confident that my project answers the question by providing a curriculum unit that uses frameworks and practices that support scientific literacy.

There are several implications of the capstone project. The first implication is that the capstone project provides an already accessible curriculum for teachers to implement that is creative and hands-on. The curriculum does not constrain the creativity and responsiveness of teachers in school, but deepens core science concepts, providing teachers and students the rigorous instruction needed to close the achievement gap in disadvantaged groups (National Research Council*,* 1996). Therefore, teachers have access to the curriculum and can apply their own creativity to the curriculum, saving time when creating lesson plans. This is also a benefit of the curriculum because most science curricula are scattered and boring, forcing teachers to have to go to outside sources to fulfill the requirements of the MN science standards. The curriculum also introduces teachers to resources in the state of Minnesota, such as the Big River Journey Workshop, that can be used to meet the needs of disadvantaged students.

Another implication is that the curriculum provides an example for teachers to use when they are creating curriculum units in other science strands or when they are adapting the curriculum unit. Teachers are able to instead focus on students and their learning outcomes and less on developing a plan for the life science strand to embed literacy into the curriculum. This is an important implication because teachers can focus on increasing the achievement of disadvantaged students. The effectiveness of the curriculum unit can truly be assessed when students are implementing the learning outcomes of a level three or higher on the Marzano scale.

A third implication is that it provides clarity to teachers. There seems to be a confusion on whether or not we are required to teach the new standards during the 2021-2022 school year.

The project answers this question by using the old science standards and science practices necessary to increase scientific literacy. This is one of the ways that the Minnesota Department of Education recommends schools to implement the new science standards. Teachers will be able to see how the old standards can be used to transition to the new standards without having to take valuable time to plan a lesson plan. The next section addresses application to the profession.

Application to the Profession

We as educators have a responsibility to ensure every student has an equal access to education. As of today, students of color remain significantly behind those of their privileged counterparts. This project is a fraction of what is necessary to close the achievement gap.

It is time for educators to take it upon ourselves to mitigate the widening gap by starting to seek professional development in science and literacy. As of right now, there is no requirement by the state of Minnesota for educators to attend clock hours in science. Although the state has added a requirement for English language learners and cultural competency, the clock hours are minimal and generally the focus is on math or reading. Developing the curriculum unit has caused me to reflect on the minimal importance of scientific literacy placed in schools and the need to make changes beyond myself and into the greater community. Teachers will continue to engage in weak science instruction until opportunities to develop arise.

On a positive note, the curriculum can be shared with my colleagues at the charter school. Administrators can record lessons of teachers teaching using the curriculum unit during annual observations. The videos could also be used as an example to teachers to observe and critique during professional development on staff development days. Grade level teams could form

Professional Learning communities (PLCs) and continue to develop the curriculum further using the frameworks applied in the curriculum unit.

Conclusion

Throughout this chapter, I discussed the purpose of the project and the major learnings that surfaced as a result of completing the project. I revisited the literature review and discussed how my literature review affected the development of the capstone project. I express the limitations, implications, and the application the capstone project had on the teaching profession. This capstone project answers the question, *How can educators embed scientific literacy into the intermediate classroom of disadvantaged groups?* Although the project is completed, there is much to be done in the areas of professional development and science curriculum planning over the next several years to embed scientific literacy into the classroom of disadvantaged students.

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Appendix A

2009 Minnesota Academic Life Science Standards Grade 5

Minnesota Standards

The curricular unit focused on the life science strand of the Grade 5 Science Minnesota State Standards. The standards that were used to design the curricular unit were Standards 5.4.1.1 and 5.4.4.1.

Life Science Standards

Standard 5.4.1.1 Living things are diverse with many different characteristics that enable them to grow, reproduce and survive.

The standard included the following benchmark:

5.4.1.1.1 Structures & Survival

Describe how plant and animal structures and their functions provide an advantage for survival in a given natural system.

For example: Compare the physical characteristics of plants or animals from widely different environments, such as desert versus tropical, and explore how each has adapted to its environment.

Standard 5.4.2.1 Natural systems have many parts that interact to maintain the living system.

The standard included the following benchmarks:

5.4.2.1.1 Relations in Living Systems

Describe a natural system in Minnesota, such as a wetland, prairie or garden, in terms of the relationships among its living and nonliving parts, as well as inputs and outputs.

For example: Design and construct a habitat for a living organism that meets its need for food, air and water.

5.4.2.1.2 Changes in Natural Systems

Explain what would happen to a system such as a wetland, prairie or garden if one of its parts were changed.

For example: Investigate how road salt runoff affects plants, insects and other parts of an ecosystem.

Another example: Investigate how an invasive species changes an ecosystem.

Standard 5.4.4.1 Humans change environments in ways that can be either beneficial or harmful to themselves and other organisms.

The standard included the following benchmark:

5.4.4.1.1 Humans & Natural Systems

Give examples of beneficial and harmful human interaction with natural systems.

For example: Recreation, pollution, or wildlife management. ("Minnesota Academic Standards," 2009).

Appendix B
SIOP Lesson Plan
Lesson 1 & 2
Week 1

MN State Standard: 5.4.1.1.1

Describe how plant and animal structures and their functions provide an advantage for survival in a given natural system.
For example: Compare the physical characteristics of plants or animals from widely different environments, such as desert versus tropical, and explore how each has adapted to its environment.

Building Background

Students should understand that animals have specific structures that allow them to survive and thrive in a specific environment. Students should be taught about Earth's different habitats or biomes and be able to describe the characteristics of some of the plants and animals living in each. Students should know that organisms live in very different environments such as oceans, deserts, tundras, forests, grasslands, and wetlands. These organisms are different from one another because their environments are different. For example, animals with thick fur are able to survive a cold habitat. Gills allow fish to obtain oxygen from water, whereas lungs allow mammals to obtain oxygen from the atmosphere. Desert plants and animals have adapted by conserving the small amount of water they require. The thick, waxy leaves of some plants prevent water loss. Many desert animals are nocturnal and search for food during the cool of night.

Cross Cutting Concept
The cross cutting concept is structure and function ("A Framework", 2012). Intermediate students can example complex structures in organisms and consider the relationship of the shapes of the parts to their functions. Students can observe a model of Galapagos and create a similar model of an organism of their choice. In the model, the student should label the structures of the organisms and the adaptation. Visualizing the model helps students connect adaptations to survival and more difficult concepts in later grades ("A Framework", 2012).

Lesson Preparation
Goal: Describe how plant and animal structures and their functions provide an advantage for survival in a given natural system.

Language Objectives: Students will
- Watch the Living River Online Fabulous Floodplain video
- Discuss verbally how river animals have adapted to life in the river and the floodplain forest

- Research and write a paragraph describing how one specific structure provides an advantage for survival
- Present their findings to the class
- **Content Objectives:** Students will
- Recognize and recall ecosystem vocabulary words: plant structures, animal structures, advantage, survival, natural system
- Describe plant and animal structures
- Describe how plant and animal structures help them to survive

Vocabulary:

Nouns:
Plant structures
Animal structures
functions
advantage
survival
Natural system

Verbs:
Describe

Strategies

Materials

- I-pad, textbook, science interactive notebook

Motivation

- The teacher will read aloud Adaptations by Monica Davies (2015). The teacher will explain that overtime adaptations have helped animals survive and change over time. The teacher will read aloud pg. 9 and discuss how cats, dogs, humans, bears and skunks have adapted to their environment. The teacher will ask students "How are their adaptations advantageous to survival?" The teacher will then ask students to think-pair-share and discuss an animal in Minnesota that has adaptations. The teacher will conclude the mini lesson and remind students of their center activity using their center sheet.

Center Activities

- Students will complete two center activities per day. The center activities should take approximately 30 minutes.
- Students will read the ecosystem encyclopedia entry and search for vocabulary words and use context clues to get a better understanding of vocabulary https://www.nationalgeographic.org/encyclopedia/ecosystem/Students will interact with vocabulary using nearpod.

- Determine the kind of ecosystem found along the Mississippi River by watching the **Living River Online Fabulous Floodplain video**.
  https://sites.google.com/parkconnection.org/livingriveronline/fabulous-floodplain
  While watching the video, students will rationalize how river animals have adapted to life in the river and the floodplain forest. They will write about how these adaptations are advantageous to survival.
- Students will read in groups Chapter 3 Lesson 1: What are some physical structures in living things? Students will engage in science student talk by reading with a group and discussing the question in Lesson 1: Growth and Survival Worksheet.

Practice/Application
While students are working, the teacher is working with students who have already watched the video. The teachers will review informational writing and facilitate student responses to the question: *How have river animals adapted to life in the river and the floodplain forest? How are their adaptations advantageous?*

Application
When students have completed the informational text writing assignment, have them present their writing to the class. Have the audience ask engaging questions and discuss responses.

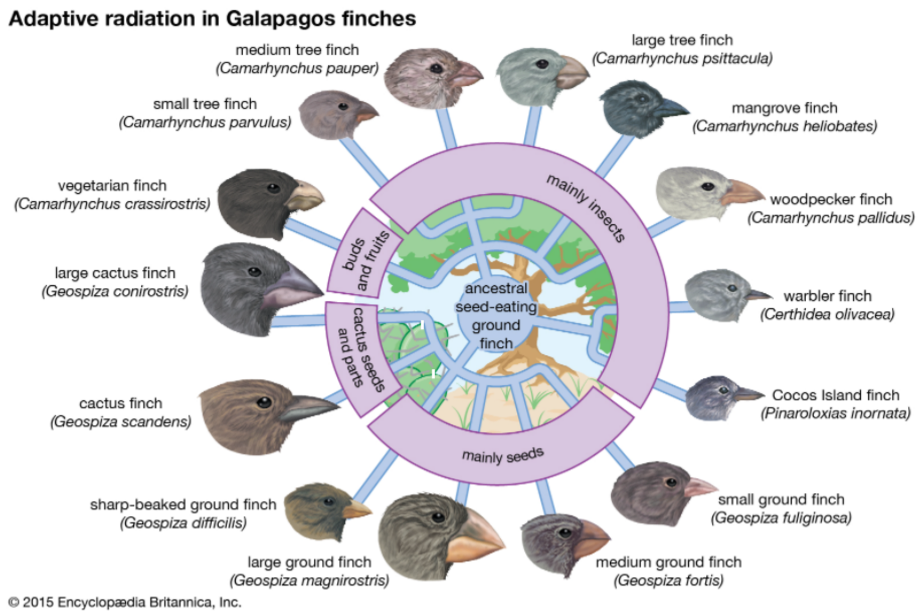
Review & Assessment
Assess students using a mastery assessment that include vocabulary, multiple choice, extended response higher order thinking questions with diagrams.

Students will also self assess their learning using Marzano scales using student handout 5.

Student Handout 1 - Using Models to Explain Adaptation

Name: ________________________ **Date:** __________________________

Directions: Observe the model of the adaptations of the Galapago finches. Describe the bird's diet, bill shape, species and adaptations in the chart below.



(Encyclopædia Britannica inc., 2015)

Note: Unit diagram for implementation of cross cutting concepts

Bird's Diet	Shape of Bill	Name of Species	Adaptation

Student Handout 2- Living River Online Fabulous Floodplain
Informational Writing Response

Name: ________________________ **Date: __________________________**

River animals have adapted to life in the river and the floodplain forest. Write an informational essay explaining different adaptations of river animals are advantageous to survival.

Include in your essay:

- two to three plants or animals
- adaptations that increase survivability

Format:

- an introduction paragraph
- a body paragraph containing information from the video and other sources
- a conclusion paragraph

Student Handout 3- Chapter 3 Lesson 1: Growth and Survival
Notes/Handout
Interactive Science Grade 5, 2016

Name: ________________________ **Date:** __________________________

Big Question: How do plants and animals grow and change?

Page number	Teacher Notes	Student Notes
101	You will learn about how organisms interact with their environments. Some organisms change over time as a result of these interactions. These changes may help plants and animals survive. Humans play a role in these changes as well. This will help you understand changes in your own environment and how organisms interact with it.	**Make a Prediction:** How do plants and animals grow and change? ________________________
N/A		What are the needs of living things? ________________________
108		Why do you think its

		important that male painted buntings are brightly colored?_____________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ _________________
109	Physical structures provide benefits to both plants and animals. Plant seeds have tough coverings that help it to survive and snakes camouflage to conceal themselves from both prey and predator.	Explain how the physical structure of white tail deer helps it survive harsh winters? ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ __________________
110	Plants have stems that stretch toward the sunlight and can hold the weight of leaves and fruit. Some plants such as trees, have wood in their stems and branches for additional support.	Higher leaves are more likely to get sunlight. How is this helpful to a plant?
112	Animals and plants breathe in different ways. Animals such as turtle break through the mouth or nose using lungs Fish take in oxygen from water through gill and	Click on Diagram of different ways organisms breath. How are the ways the organisms breathe similar? How are they different?

	insects take in oxygen from structures called spiracles.	______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ___________________
All pages	Review pages 100-112 and your notes.	What adaptations allow plants and animals to meet needs in different environments?_________ ___

Student Handout 4- Adaptations Assessment

Name: ________________________ **Date:** __________________________

Habitat Change

A small, short-furred, gray animal called a divo lives on an island. This island is the only place on Earth where divos live. The island habitat is warm and provides plenty of the divos' only food—tree ants. The divos live high in the treetops, hidden from predators.

One year the habitat experienced a drastic change that lasted for most of the year. It became very cold and even snowed. All of the ants died. The trees lost their leaves, but plenty of seeds and dried leaves were on the ground.

(Keeley, 2007)

1. Circle any of the things you think happened to most of the divos living on the island after their habit changed. ***2 pts***

   A The divos' fur grew longer and thickers.

   B The divos switched to eating seeds.

   C The divos dug holes to live under the leaves or beneath rocks.

   D The divos hibernated through the cold period until the habitat was warm again.

   E The divos died.

2. Explain your thinking. How did you decide what effect the change in habitat would have on most of the divos? ***5 pts***

3. Loggerhead sea turtles are large turtles that live in the ocean and nest on the Florida coast. The female loggerhead sea turtle lays more than 100 eggs in the beach sand. How is laying so many eggs an important adaptation that helps these turtles to survive? ***2 pts***

A. Large nests of eggs help keep the eggs warm enough to allow more turtles to hatch

B. If many turtles hatch, they can help defend each other against predators in large numbers.

C. The more eggs that are laid, the greater the chance that more turtles will live to become adults.

D. A large number of eggs in one place makes it possible for the mother to lie on the eggs until they hatch.

4. What questions do you have about adaptations?

Student Handout 5 - Marzano Scales Self Assessment

Name: ________________________ **Date:** __________________________

Self assess your learning. **Circle** your level of understanding of adaptations.

Level	
4	I understand adaptations so well I can teach it to someone.
3	I can describe how plant and animal structures and their functions provide an advantage for survival in a given natural system
2	I can identify plant and animal structures. I can select a function that provides an advantage for survival when given choices
1	I can define adaptations
0	I need help

Give reason to support the level you selected. What do you need to review to change your level?

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SIOP Lesson Plan
Lesson 3 & 4
Week 2

MN State Standard: 5.4.1.1.1

Describe how plant and animal structures and their functions provide an advantage for survival in a given natural system.
For example: Compare the physical characteristics of plants or animals from widely different environments, such as desert versus tropical, and explore how each has adapted to its environment.

Building Background

For any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all. Organisms interact with one another in various ways besides providing food. Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful.

Cross Cutting Concept
The cross cutting concept is structure and function ("A Framework", 2012). Intermediate students can examine complex structures in organisms and consider the relationship of the shapes of the parts to their functions. Students can understand the adaptations of birds by using representations of beaks to explain the proper habitat for each bird. Students examine structure and function by using hands-on materials such as tongs, tweezers, and other utensils to understand adaptation.

Lesson Preparation
Goal: The student will learn and describe how different kinds of birds' beaks have adapted to feed on different foods within a specific habitat.

Language Objectives: Students will
- Read about the four habitats and discuss compare and contrast.
- Summarize the habitat they are best suited to

Content Objectives: Students will
- Navigate through simulated habitats using an assigned "beak" and pick up as many food items as possible
- Use the habitat record sheet to determine the most suitable habitat
- Describe how the bird's beak helped them survive

Vocabulary:

Nouns: **Verbs:**

Plant structures	Describe
Animal structures
functions
advantage
survival
Natural system
Marsh
Pond
Forest
Prairie

Materials

- Big River Journey Teacher Guide p. 64-70
- Simulation habitat equipment
- 2 containers of water: one shallow (2” of water), one deep (10” or more water)
- 4 tweezers
- 4 tongs with tape over tong
- 4 long handled salad tongs
- 4 pliers
- 1 package of rice or popcorn
- 1 packages of sunflower seeds
- 1 stump with holes in it for rice or popcorn any floating and non-floating objects, such as cut-up straws 1/2 inch long, raisins

Motivation

- Read and explain the content and language objectives of this lesson to the students. Say, “Let’s look at our language objectives for today” and then read language objectives aloud and discuss. “Now let’s look at our content objectives for today.” Read content objectives and cross cutting concepts aloud and discuss. Tell students that they are going to become different types of birds and use tools to identify the habitat and diet of the bird. Have students discuss what the tools represent and make predictions of which birds are best suited for which habitat.

Presentation

- Tell the students that they are going to become different kinds of birds. Show them the different “beaks.” These include the tongs, tweezers, and other utensils. Explain to the group that their job is to find the proper habitat for which each bird is suited. Mention that the tools or “beaks” give some clue of what a bird eats and where it may live. Show the students four habitats. See Simulated Habitats (Insert A). As you move into each new habitat, give a short description of the habitat and have students talk and discuss living and non living components of the habitat.

- The four habitats are marsh, pond, forest, and prairie. Divide students into groups of four. Each group receives a different tool (i.e. one group receives pliers; one group receives tweezers, etc.). Groups will keep the same tool throughout the whole activity. Tell the students they will move from one habitat station to the next. They will have 30 seconds at each habitat station to eat as many food items as possible. The students must keep one hand behind their backs and cannot let their hand get wet.

- Explain to students for food to qualify as eaten:
  Marsh: Floating objects must be dropped in another container and hands can't touch the water.
  Pond: Sinking objects or other non-floating objects must be dropped in another container and hands can't touch the water.
  Forest: Rice/popcorn must be dropped in another container, can't be dropped on the floor.
  Prairie: Sunflowers must be crushed over a container and the nut taken out.

- Emphasize to students that they are not competing against one another. Remind them that they are trying to find the habitat that they are best suited to. Have the students record the number of food pieces eaten on the Habitat Record Sheet (Insert B).

Practice/Application

Students move through one habitat station to the next in 30 second intervals. The students must keep one hand behind their backs and cannot let their hand get wet. Students must also follow the guidelines for food to qualify as eaten. Students record the number of pieces eaten on the habitat record sheet.

Application

When the activity is completed, have the student graph their results and discuss.

Review & Assessment

Have groups summarize their learning using the Habitat Record Sheet (Insert B). Have the audience ask engaging questions to the group and discuss responses

Student Handout 5-Birds, Beaks, and Adaptations

Directions: Have all groups record the number of food pieces "eaten" from each habitat with each tool.

	Pond	Marsh	Forest	Forest	**RESULTS**
BEAKS					
Pliers					
Short Tongs					
Long Tongs					
Tweezers					

Summarize

Write a summary explaining the best suitable habitats for each beak. In your summary, use the facts from Simulated Habitats (Insert A) to support your writing.

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SIOP Lesson Plan
Lessons 5 to 8
Week 4

MN State Standard: 5.4.4.1.1
Give examples of beneficial and harmful human interaction with natural systems. *For example:* Recreation, pollution, or wildlife management.

Building Background

Human activities have major effects on land, vegetation, streams, ocean, air and outer space. Human activities in agriculture, industry and everyday life can impact the environment in a beneficial or harmful way. Individuals and communities are making efforts to reduce their environmental imprint by reducing the amounts of materials they use, treating sewage and imposing rules and restrictions on water use and regulating sources of pollution such as emissions from factories, power plants, or the runoff from agricultural activities ("A Framework", 2012).

Cross Cutting Concept
The cross cutting concept is system and system models ("A Framework", 2012). A unit of investigation can be referred to as a system. A system is an organized group of related objects that form a whole. In the context of this lesson, the system refers to the natural system and the beneficial and harmful interactions within the system. The natural system will serve as the focal point and the human interactions and the effects of those actions are represented outside of the boundary.

Lesson Preparation
Goal: Students will be able to explain beneficial and harmful human interactions with natural systems. *For example: Students will research the environmental impact of everyday plastics. Students will learn which plastics are beneficial to the environment and which plastics are harmful or hazardous.*

Language Objectives: Students will
- Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.
- Present information that using powerpoint or other visual aids to help the audience connect and understand their information

Content Objectives: Students will
- Create a mind map using PIXIE to explain beneficial human interactions with natural systems
- Create a mind map using PIXIE to explain harmful human interactions with natural systems

Vocabulary:

Nouns:	**Verbs:**
Human interactions	Explain
Beneficial interactions	Integrate
Harmful interactions	Create

Materials

- Creative Learning Systems Smart Lab Program
- Science Interactive Textbook
- Notebook
- computer

Motivation

- The teacher will review expectations in the **S**cience **T**echnology **E**ngineering **A**rts and **M**athematics lab prior to starting the lessons. The students will open the launchpad, login and click on the sustainability tab.
- The teacher will present students with engaging questions to introduce the lessons for the next 3-5 days. The teacher will ask: *What is plastic? How do humans use plastic? Is plastic beneficial or harmful to the environment?* Students will discuss their responses verbally.

Presentation

- The teacher will direct students to read the challenge section in the Level 1- Reusing and Recycling Plastic Module. The teacher will explain to students that the module consists of four sections. The four sections are: *Your challenge, What You Should Know, Do It!, and Extend Yourself.* The timeline of each section varies with some students finishing in three days and other students finishing in four or five days. If students finish in a shorter time frame, direct students to the *Extend Yourself* section.
- The teacher will then tell students to read the *Your challenge* section and ask students to discuss what they will learn. Students will write their learning goals and targets in their science interactive notebooks.

Practice/Application

- Below is a possible guideline of activities and assignments.
- **Day 1 -** Students will answer the questions on the What you should know worksheet. Students will bring one to three examples of plastics they use at home and/or school.
- **Day 2 -** The teachers will collect the plastics and place four to ten plastics at each peninsula. The students start the second section: *Do It!* by reading about plastic codes.

The students will determine the types of plastic codes they are using by completing the *Plastic Codes* worksheet .

- **Day 3 -** Students will open PIXIE program and review how to use PIXIE by going to Recipes4success in PIXIE. "Recipes" are projects to help you learn Pixie. "Snacks" are tips and tricks for using PIXIE. Students will create a comic that will teach others about the benefit and harm of human interactions with the natural system. They will include what they learned from the Level 1- Reusing and Recycling Plastic Module.

Review & Assessment

- **Day 4 -** Students will create a mind map of the harmful and beneficial human interactions and the impact on the natural system. Students will use Pixie and the Mind Mapping Diagram Template to create the mind map. This will be the culminating activity.

- **Application**
  When students have completed the mind map, have them present their mind map to the class. Have the audience ask engaging questions and discuss responses.

Student Handout 6-What You Should Know

Name: ______________________________ **Date:** ______________________________

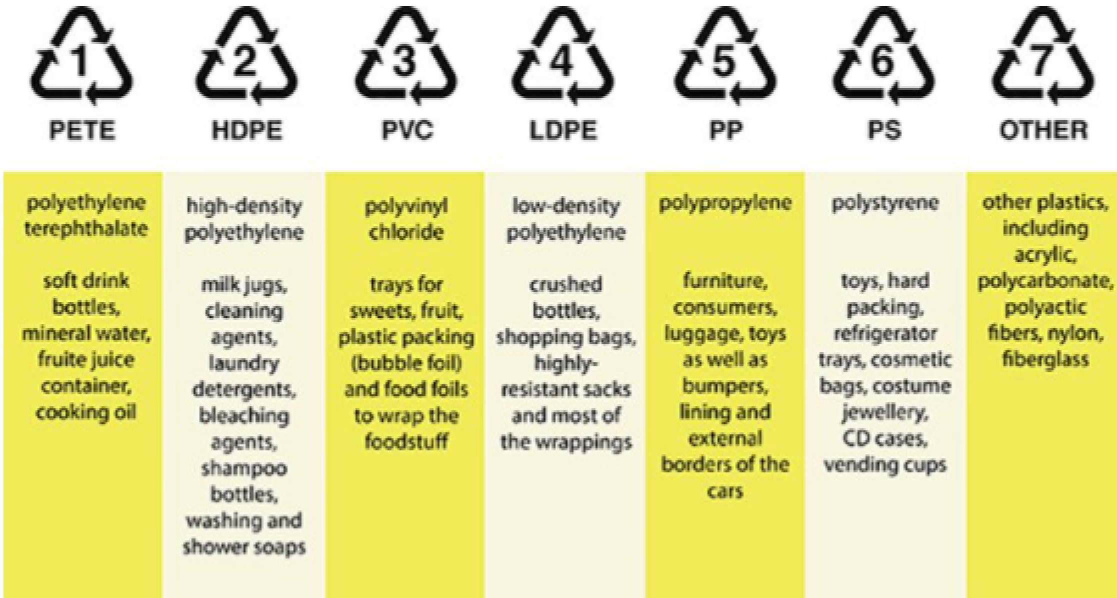
Question	**Answer**
What is plastic?	____________________
Are plastics decomposable? How long does it take for plastic to break down?	____________________
Where do plastics often end up?	____________________
What is the Great Pacific Garbage Patch?	____________________
What is the most commonly used plastic?	____________________
What is the most commonly recycled plastic?	____________________
What plastic is used for food wrapping, computer cables and gardening equipment? Is this plastic recyclable?	____________________
What plastic is reusable, but not always recyclable?	____________________
Which plastic is reused and recycled, but at a percentage rate of less than 10%?	____________________
What plastic is used to make baby bottles, water bottles and other common plastic products?	____________________
What alternatives are being developed to	____________________

replicate plastic?	______________________________

Student Handout 7- Plastic Codes

Name: ________________________________ **Date:** ________________________________

Directions: Observe each plastic item at your peninsula. Use the image below to identify plastic code. Use the *What You Should Know* section to classify the item as recycle, reusable, both or neither. Then, research the environmental impact of the product using the internet.



(Creative Learning Systems, 2021)

Item	Plastic Code	Recyclable? Reusable?	Environmental impact Beneficial/Harmful

Student Handout 8- Alternatives to Plastic

Name: ______________________________ **Date:** ______________________________

Reduce Your Use

Did you know that is takes 15 to 1,000 years for a typical plastic grocery bag to break down? Are there items you use everyday that are made out of plastic that you could find an alternative for? Can you reduce your plastic use? Research alternatives for commonly used items like food and drink containers, plastic wrap, plastic bags, water bottles, etc.

Directions: Research alternatives for commonly used items like food and drink containers, plastic wrap, plastic bags, water bottles, etc.

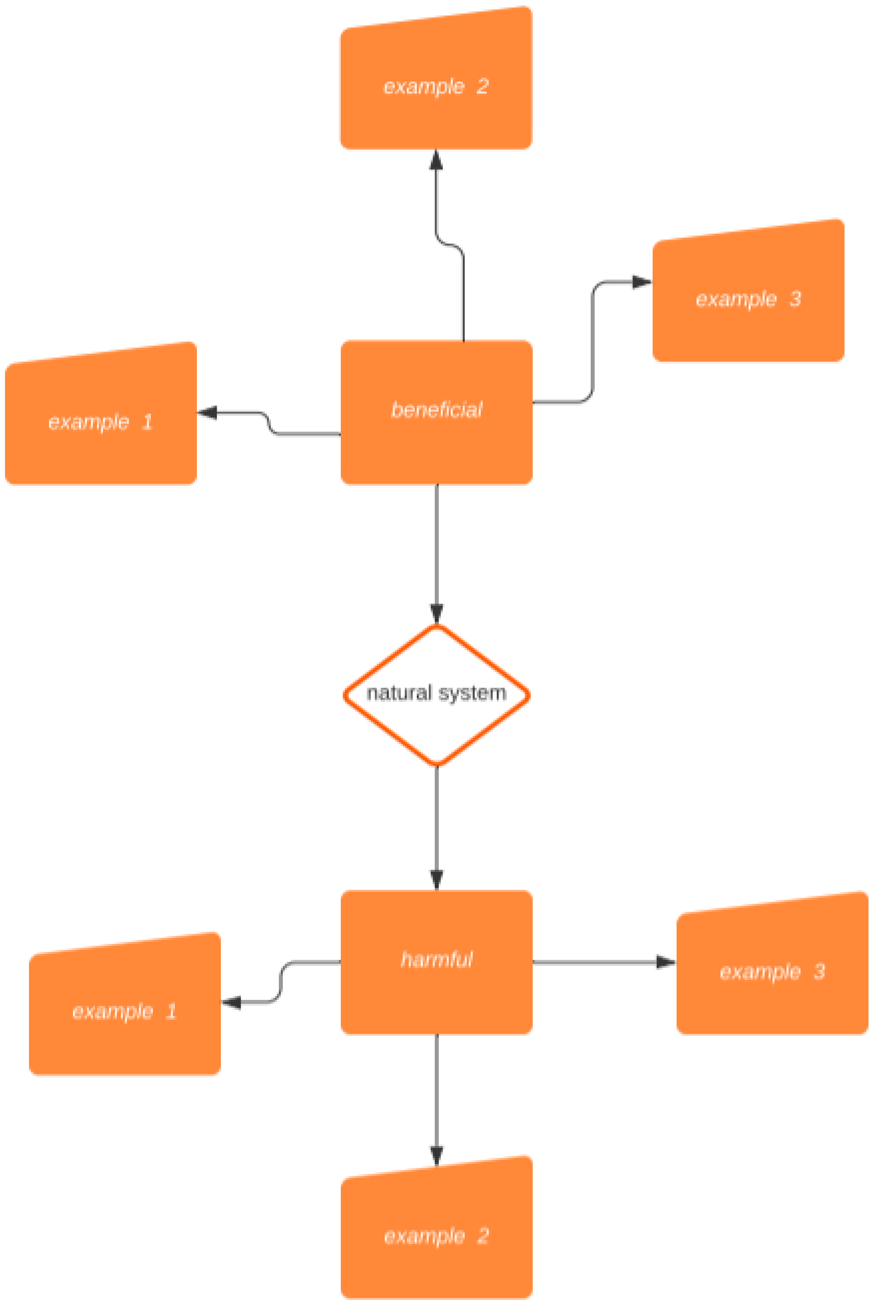
What are alternatives to food and drink containers?

What are alternatives to plastic wrap?

What are alternatives to plastic bags?

What are alternatives to water bottles?

Student Handout 9- Mind Mapping Diagram Template



Appendix C

Table 1. Assessment of Project

Statement	**Response**
	Strongly Disagree Disagree Neutral Agree Strongly Agree
The curriculum unit provides opportunities for students to engage in inquiry and hands-on learning.	
The curriculum provides opportunities for students to engage in student centered learning.	
The curriculum provides opportunities for students to engage in academic writing.	
The curriculum uses phenomenon based instruction (i.e cross cutting concepts).	
The curriculum uses rigorous assessments.	
The project effectively answers the capstone question.	

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