INVESTIGATING THE IMPACT OF INQUIRY-BASED LEARNING ON STUDENTS QUESTIONING SKILLS IN TITLE 1 SCIENCE CLASSROOMS

by

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DEDICATION

To my students, you have pushed me to be creative in my teaching and given me grace as I learned and grew alongside you.

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ABSTRACT

Students are naturally curious about the world around them. However, they struggle with formulating questions that can be scientifically investigated. In science instruction, student curiosity can be harnessed by encouraging students to pose and answer investigable questions. This action research investigated the impact of inquiry-based learning on students' questioning skills. Students were exposed to four different phenomena and observable events related to the properties and changes of matter. They were also given a graphic organizer utilizing the Question Formulation Technique to generate and improve their questions. Data was collected using pre-tests, post-tests, student surveys, educator observations, and student interviews. Results showed that students' questions improved and changed from observational to explanatory from the pre-test to the post-test; they had a deeper understanding of the instructional content and reported growth within themselves. These findings suggest that inquiry-based learning can improve the quality of student questions and deepen students' understanding of scientific content. Future research could investigate more targeted strategies to encourage higher-order thinking questions in areas like engineering or systems thinking.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

School Demographics

Whittier Elementary School is an urban K-6 school with a current enrollment of 478 students, located in a densely populated neighborhood in downtown Salt Lake City. Many of our students walk to school, reflecting a strong sense of independence and community belonging. The school serves a vibrant and diverse population, including many immigrant and refugee families who contribute a wide range of languages, traditions, and global perspectives to the classroom. While the neighborhood's average household income is approximately half of the state median (U.S. Census Bureau, n.d.) our students consistently demonstrate remarkable resilience, determination, and creativity. Despite facing economic challenges, they bring a wealth of lived experiences, cultural knowledge, and problem-solving skills that enrich our learning environment. These strengths are honored and celebrated throughout our school community.

Whittier is a Title 1 school, receiving supplemental federal funding to ensure all students, regardless of socioeconomic background, have access to high-quality education (National Center for Education Statistics, 2009). Currently, 73% of our students qualify for free lunch and breakfast (Salt Lake City School District (SLCSD), 2022), which reflects broader systemic inequities, not a lack of ability or motivation. Our students work hard, support on another, and show deep curiosity and enthusiasm for learning. Our student population reflects a broad racial and cultural spectrum: 12% African American, 7% Asian, 30% Caucasian, 42% Hispanic, 3% Native American, 3% Pacific Islander, and 4% Multi-Ethnic, with a total of 69% of students identifying as part of a racial or ethnic minority group (SLCSD, 2022). This diversity fosters meaningful conversations and learning opportunities, as students regularly share their cultural experiences and linguistic strengths, creating an inclusive and globally minded school community.

I have been teaching 5th grade for one year, and I currently have 16 students in my class. I am one of three fifth-grade teachers at my school and collaborate with the other fifth-grade teachers as the upper elementary team. Fifth grade is a self-contained classroom, so I am responsible for teaching all the subjects. My students come to class with a very diverse set of learning needs. I focus on differentiating my lessons to make the content accessible and equitable for all my students. I use a guided discovery method during my inquiry lessons that allows me to scaffold by creating structured tasks, giving feedback, and asking probing questions (Honomichl & Chen, 2012). Access to reliable transportation, childcare, and internet at home remains a challenge for many families, impacting student attendance and academic consistency. My goal and responsibility as an educator is creating content that everyone can access.

Our school is under surveillance by the state of Utah as a turnaround school under a program called Targeted Support and Improvement (TSI). This means that our school has a student group that is one of the lowest performing 5% of Title 1 student groups in the state of Utah, and there are specific goals and standards we must achieve every year to exit the program (Utah State Board of Education (USBE), 2023). Our targeted student group is our Hispanic population. This student group has scored below the Title 1 5% threshold for two consecutive years. Addressing these challenges requires a diverse approach that prioritizes targeted interventions, equitable resources, and community support to help students reach their full potential.

Context of Study

The state of Utah adopted and modified the Next Generation Science Standards (NGSS) as a framework for science education standards. Within this framework, there are three dimensions of science, and they are articulated as science and engineering practices (SEPs), crosscutting concepts (CCCs), and disciplinary core ideas (DCIs) (NGSS Lead States, 2013a). I thought asking questions would be the best place to start. As a science educator, one tool I want to harness in my classroom is motivating and guiding my students to develop relevant, testable questions. Relevant questions are the start of scientific inquiry. If I can encourage my students to create meaning out of lessons by developing relevant questions, I can see an increase in student engagement and learning. Considering the high proportion of multilingual learners, students affected by poverty, and achievement gaps noted by the TSI report, fostering student engagement through inquiry is a high priority. Developing strong questioning skills in science aligns with the NGSS standards and helps build confidence and increase academic performance among underrepresented student groups.

In designing this study, I intentionally focused on the strengths my students bring into the classroom such as their perseverance, collaboration, and rich cultural backgrounds. Inquiry-based learning allows students to draw from their lived experiences, family knowledge, and multilingual capabilities to ask personally meaningful and relevant questions. My goal with this approach was to build their critical thinking skills as well as affirm their identities as capable scientists and learners.

Focus Question

My focus question was, How does implementing inquiry-based learning affect the development of questioning skills in Title I science classrooms?

My sub-questions include the following:

1. How do Title I students perceive their own growth and development in questioning skills as a result of engaging in inquiry-based learning activities?
2. How does inquiry-based learning impact the quality of students' questioning skills in Title I science classrooms?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Background

Inquiry-based learning has the potential to close the achievement gap in science education. Science education has adopted the Next Generation Science Standards, which focus on creating inquiry-based learning experiences for students (NGSS Lead States, 2013a). Scientific inquiry aims to empower students with skills, knowledge, and attitudes to develop into independent thinkers (Llewellyn, 2014). Students participating in inquiry-based classrooms show increased engagement and develop critical thinking skills (Weissman, 2023). My goal is for students to do the majority of the thinking and problem-solving in the classroom, and an inquiry learning approach may support that goal in my classroom. Students of color and students from low socioeconomic backgrounds are underrepresented in science; only 5% of STEM Ph.D.s in 2021 were awarded to Black scientists, and only 8% were awarded to Hispanic scientists (Weissman, 2023). As inquiry-based learning is a powerful tool in teaching science, it can be harnessed in every classroom to increase student engagement and decrease the science achievement gap. Inquiry-based learning equips students with the skills to become successful scientists.

The Role of Student Questioning in Inquiry-Based Science

Inquiry-based learning is focused on the learner making discoveries based on their questions instead of a lecture-style class. This cycle works as a format for teachers to develop more engaging lessons for their students. As stated by Llewellyn (2014) the inquiry cycle has six levels:

1. Inquisition – stating a “What if” or “I wonder” question to be investigated
2. Acquisition – brainstorming possible procedures
3. Supposition – identifying an “I think” statement to test
4. Implementation – designing and carrying out a plan
5. Summation – collecting evidence and formulating claims and explanations
6. Argumentation – communicating claims, evidence, and explanations to others (p.18).

These levels ensure that students have access to the entire scientific process as a scientist in the field would. For students to begin the inquiry cycle, there needs to be a phenomenon that acts as a hook and is presented as an observable event (Anderson, 2020). The purpose of the phenomenon is to shift the focus from learning about a topic to figuring out why or how something happens (NGSS Lead States, 2013a). This taps into students' natural curiosity and creativity. This makes the learning flip from being driven by the teacher to being driven by the student, who becomes the active investigator and uses the teacher for support and guidance (Anderson, 2020; Edelson et al., 2021). Students can make the investigation unique to what is important to them instead of what is important to the teacher or the textbook. In this model, students drive their learning and experience science in a way that mirrors what scientists in the field are expected to do.

Developing good questions is a skill that students need to access the richness of scientific inquiry. As stated by NGSS Lead States (2013c) the ability to create a question and define a problem is an essential process for scientific investigations. Students use the questions they create to guide their research and help them construct knowledge from the phenomena (Anderson, 2020; Chin & Brown, 2002; NGSS Lead States, 2013c). Within inquiry learning, the goal is for students to ask open-ended questions that require an investigation and cannot be answered quickly (Chin & Chia, 2004). This process might require additional scaffolding from the teacher, but the teacher's role is to act as a facilitator and allow the students to direct their investigation. Vygotsky's (2022) theory, the zone of proximal development, supports the inquiry process because students can access concepts higher than their potential when they work with their peers and have scaffolding from their teacher. Deep learning occurs when students enter this zone, and the lack of structure within the zone of proximal development also supports higher levels of student thinking instead of a step-by-step prescriptive process (Chin & Chia, 2004). Through collaborative conversations, students can develop higher-level thinking questions as compared to if they were working individually. Through scaffolds, conversations, and guidance from the teacher, students can develop their own questions that will guide their investigation.

Generating good questions does not come naturally, and it is a skill that requires critical thinking. Critical thinking encompasses high-level cognitive functions such as memory, the ability to compare and contrast, inferencing, and drawing on personal life experiences (Delamain & Spring, 2020, pp. 10–11). Research has shown that student-developed questions happen with low frequency in the classroom and are often low-level questions that do not require deep thinking (Mehdi Alaimi et al., 2020). To support students in developing this skill, Muhamad Dah and Mat Noor (2021) introduced the Inquiry Question Formulation Technique (IQFT), a tool adapted from the Question Formulation Technique (QFT) designed to align with NGSS practices. This tool guides students to generate their questions with autonomy and promotes a deeper learning process, helping them to develop confidence in their scientific reasoning. This is particularly relevant in Title 1 classrooms, where students might not see themselves reflected in the traditional science content. Drawing on students' funds of knowledge, a term used by González et al. (2005) to describe the cultural and historical knowledge students bring from their homes, can help to bridge that gap. Researchers Chin and Osborne (2008) discovered that students report feelings of happiness, excitement, and pride when they can investigate questions they asked. Educators can foster academic success and a stronger sense of scientific identity by using students' background knowledge and empowering them to ask meaningful questions.

Equitable Inquiry-Based Science for Title 1 Students

Persistent disparities in science achievement across the United States highlight systemic inequities rather than student capabilities. National data show that students eligible for the National School Lunch Program (NSLP), a measure for lower socioeconomic status (SES), score an average of 140 on the science assessment, compared to an average of 166 for their non-eligible peers (U.S. Department of Education, 2019). While forty-nine percent of students from higher-income households are deemed proficient in science, only 20% of students from lower-income households reach the same benchmark. In Utah, 21% of economically disadvantaged students scored proficient on the state science assessment (Utah State Board of Education, 2023). These achievement gaps start early as students from lower SES backgrounds face opportunity gaps that their more affluent peers do not, such as lower access to high-quality preschools and childcare, and attending underfunded schools with high teacher turnover (Morgan et al., 2016). These gaps persist through eighth grade and are highly predictive of later academic and career outcomes. Early engaging science instruction and school SES desegregation are suggestions from the Morgan et al. (2016) study to close the achievement gap in science. Systemic inequities, not student potential, have formed a science achievement gap for low SES students.

These gaps reflect opportunity differences in access to high-quality science instruction, resources, and culturally responsive pedagogy, not a lack of ability. Research shows that performance on standardized tests is strongly influenced by access to academic supports and enrichment opportunities, which are often distributed inequitably (Yu, 2018). Without intentional intervention, these patterns reinforce long-standing barriers to college access and future STEM pathways. However, a study run by Geier et al. (2008) in Detroit's Public Schools shows a large effect size of academic achievement on standardized tests from students and teachers who participated in a year-long inquiry-based science curriculum program. When students from historically underserved backgrounds are provided equitable learning environments that tap into their curiosity, resilience, and prior knowledge, as inquiry-based science does, they can achieve higher academic status. Shifting science instruction to include meaningful engagement, relevance, and critical thinking empowers all students, especially those in Title 1 schools, to see themselves as scientists and innovators.

Scaffolding Question Development in Diverse Classrooms

A challenge teachers face when doing inquiry-based learning is teaching students how to produce high-quality, investigable questions. The Right Question Institute (2018) developed strategies to generate and improve questions for educators to use in their classrooms with their students. The strategy is broken down into four steps: 1. Ask as many questions as you can. 2. Do not stop to discuss, judge, or answer. 3. Record exactly as stated. 4. Change statements into questions (Right Question Institute, 2018). During an inquiry lesson, these are the steps a student follows after the phenomenon has been presented. This scaffold is effective because it takes the pressure off students to perform to perfection and emphasizes the brainstorming piece. There has also been a shift from teacher-driven to student-led, with the Question Formulation Technique (QFT) scaffold. Researchers Muhamad Dah and Mat Noor (2021) used a modified QFT scaffold and noted that students produced higher-quality questions after each cycle. The QFT is a blank document and can be used across disciplines within the classroom, making it more accessible and routine for students. Research conducted by Akuma and Koenen (2025) states that using tools such as planning templates, student thinking prompts, and reflections enables educators to anticipate student responses and adapt instruction. For teachers in Title 1 schools who face time constraints and diverse needs, these structured supports can make implementing a questioning routine more feasible and appropriate for their students.

Professional development for educators must also address cultural needs for their students. One study emphasized that inquiry-based instruction alone is not enough for success, teachers must also be aware of how to integrate their students' background knowledge into the lessons. For example, a project involving novice white teachers in a low-income school setting revealed that even well-intentioned inquiry efforts fell short when teachers lacked cultural awareness (Kang, 2019). This shows the need for a culturally responsive curriculum. The Next Generation Science Standards (NGSS) were developed with equity at their core, as outlined in Appendix D, "All Standards, All Students" (NGSS Lead States, 2013b). NGSS emphasizes inclusive practices, recognizing diverse cultural contributions to science and encouraging students to apply science and engineering to real-world problems, like water quality, air pollution, and urban gardening (Lee et al., 2013). The combination of NGSS-aligned inquiry with culturally relevant lessons can help students see themselves as contributors to science, not just consumers of it.

Conclusion

Students in Title 1 schools bring a wealth of cultural knowledge, lived experience, and resilience to the classroom, qualities that can drive scientific exploration when supported by inclusive teaching practices. While systemic inequities have contributed to science achievement gaps nationwide, research shows that strategies such as inquiry-based learning and culturally relevant pedagogy can create deeper engagement and academic success in students. This paper focuses on developing students' questioning skills through inquiry-based science instruction. In this approach, students observe phenomena, pose their own questions, design investigations, analyze results, and communicate findings, engaging in authentic scientific practices that mirror the work of professional scientists (Llewellyn, 2014). When teachers intentionally connect science learning to students' cultural backgrounds and prior knowledge, they create classrooms where all students can see themselves as capable investigators, problem solvers, and future scientists.

CHAPTER THREE

METHODOLOGY

Demographics

Science education shifted its focus from teaching content knowledge to integrating knowledge with science and engineering practices (SEP). The term practices implies the integration of both knowledge and skills in the science inquiry process (NRC, 2012). The first SEP for the K-12 classroom is the practice of asking questions. The ability to ask researchable questions is important for the science inquiry process and is also an important component of scientific literacy (NRC, 2012). Children are born with a natural curiosity and will develop their questions and possible solutions before it is formally taught in schools (Cellitti & Wright, 2019). This study used an observational case study and a descriptive research design to collect both qualitative and quantitative data about the effects of inquiry-based learning on students' questioning skills. The research question was, How does implementing inquiry-based learning affect the development of questioning skills among Title I students in science classrooms? My mixed-methods design tested if the quality of student questions increased during inquiry-based learning and if students were able to perceive their growth. Looking at the impact of inquiry-based learning on students' questions can help educators meet students' needs and inspire growth.

The study was conducted using fourteen 5th-grade students at Whittier Elementary over four weeks (*N*=14). Two students in my class did not participate in the study. In my classroom, I currently have fourteen students who qualify for English Language Development (ELD) services, three students who qualify for Individualized Educational Plan (IEPs), one student who qualifies for a Behavior Individualized Plan (BIP), and five students who qualify for Enrichment Learning Plan (ELP). Some students qualify for more than one program. The ethnicity report of my class states that I have 15% of students identify as Asian, 19% as black or African American, 42% as Hispanic, 12% as White, 4% as multi-racial, and 8% as Middle Eastern. I have 50% of students who identify as female and 50% of students who identify as male. My homeroom class has a diverse group of students with backgrounds from different geographical locations around the world. Eleven languages are spoken in my classroom, with Spanish, Arabic, and Tibetan being the most common after English. This cultural and linguistic diversity enriches classroom discussions and creates unique opportunities to connect science topics with students' lived experiences.

I have a range of reading and math levels, with students at a kindergarten level and students at an eighth-grade level. Our beginning-of-the-year assessments have placed my class average around fourth grade for reading and math levels (B. Conely, personal communication, October 4, 2024). According to our beginning-of-the-year data, 44% of my students are at or above grade level for reading, while 57% are below or well below the reading benchmark. For our math scores, 20% of students are at or above the benchmark, while 80% are below or well below the benchmark. The research methodology for this project received an exemption by Montana State University's Institutional Review Board, and compliance with work with human subjects was maintained (Appendix A).

Treatment

There are specific types of research designs that are appropriate for teacher-led action research. The qualitative research design I used was observational case studies, and it was a non-experimental design. This research design has typically been used in clinical fields such as psychology, medicine, or education and uses various methods such as observations, interviews, and field studies (Hamel et al., 1993). As I was the classroom teacher and conducting classroom-based action research, I was a full participant in the observational case study (Mertler, 2020). This was a structured research design because I looked for specific things throughout the lesson. The limitations of this research are observer bias because it was my class of students and demand characteristics, where my students may have changed their behavior because they knew they were being observed (Carmichael & Taylor, 2017). I challenged these limitations by using other data points besides just the observational data. The study used a descriptive research design. This allowed for the comparison of student responses before and after the inquiry intervention to determine if it was effective (Mertler, 2020).

Data was collected during the treatment plan. The inquiry intervention activities were the treatment plan implemented for the group of students (N=14). The class was instructed using the inquiry design model; students observed a phenomenon and developed questions to investigate based on it. Four different phenomena were used over the four weeks. The teacher presented the phenomenon and students had a chance to implement it themselves or observe it through a video.

The questioning scaffold used was the Question Formulation Technique (QFT) from the Right Question Institute (Right Question Institute, 2018). It was presented as a PowerPoint presentation and a worksheet for students. The PowerPoint slide showed the four steps students were to take after they observed the phenomenon: 1. Ask as many questions as you can. 2. Do not stop to discuss, judge, or answer. 3. Record exactly as stated. 4. Change statements into questions (Right Question Institute, 2018). After completing the brainstorming session, students had to categorize their questions as either open- or closed-ended questions and then change one open question to a closed question or one closed question to an open question. Next, students would prioritize the questions based on which ones they think are most likely to be investigated. Finally, we would have a class discussion and share the questions students came up with at their tables.

Culturally Relevant Phenomenon

As part of the inquiry-based intervention, four hands-on phenomena were selected to align with the Utah 5th Grade Science Standards and my students' cultural and environmental context. Each phenomenon was chosen to reflect students' lived experiences and promote deeper engagement. The lessons aligned with Strand 5.2 Properties and Changes of Matter, focusing on two standards from the topic, which were 5.2.1 and 5.2.3 (Utah State Board of Education, 2024, p. #14).

The first two lessons focused on air inversion, a significant environmental issue in Salt Lake City that directly affects the health and daily life of many students and their families. In one investigation, students observed a beaker experiment in which hot and cold water were layered differently. When the hot water was on top and the cold water on the bottom, no mixing occurred, visually modeling the atmospheric layering that causes inversion. In contrast, reversing the layers led to mixing, helping students visualize how trapped cold air and pollution stay in the valley. A second phenomenon used a time-lapse video of Salt Lake City during an inversion, showing the smog stuck in the valley while the mountains stayed clear. All my students have firsthand experience with poor air quality and limited outdoor activity during inversion periods. Some of my students have asthma and are not allowed to be outside for any period of time during inversion periods. These activities served as culturally relevant anchors for scientific questioning, tapping into prior knowledge and concerns from students' home and community environments.

The third and fourth phenomena involved the chemical reaction of baking soda and vinegar, designed to introduce students to gas production, changes in matter, and cause-and-effect reasoning. In one lesson, the reaction occurred in a plastic bag to demonstrate the buildup of gas and pressure. Some bags popped for dramatic effect. In another experiment, the experiment was repeated with a balloon placed over the beaker to capture and visualize gas expansion. To promote inquiry, groups were given different reactants (water vs. vinegar), prompting them to investigate variables and make predictions based on observations. These accessible, kitchen-based experiments reflected common materials from students' everyday lives and encouraged collaborative exploration. After students completed the experiments in the classroom, a few went home and introduced them to their families.

The pre- and post-test used in this study were designed to reflect the local context of the Great Salt Lake shrinking and the scientific concepts aligned to students' lived experiences. Students watched a time-lapse video showing the Great Salt Lake shrinking from 1987 to 2016 and then came up with three investigable questions. By creating an assessment aligned with the phenomenon used during instruction, the test questions allowed students to demonstrate their conceptual understanding of the changes occurring in the Great Salt Lake. This approach supports equitable access to science learning by validating students' background knowledge and minimizing linguistic or cultural barriers to comprehension. According to NGSS Lead States (2013b), equity-based assessment practices should "connect students' interests and experiences to scientific phenomena and practices," ensuring that students see the relevance of science in their own lives. Keeping the assessments relevant to local contexts made students more likely to engage critically and reflect on their learning.

Culturally and locally based phenomena promote curiosity and questioning. It also supported equity and inclusion by validating students' personal and environmental knowledge, which is considered to be a part of a student's "funds of knowledge" (Gonazalez et al., 2005). This approach aligns with the NGSS, which emphasizes equitable science instruction through the principle of "All Standards, All Students" (NGSS Lead States, 2013b). Instruction is more meaningful by utilizing students' background knowledge, home experiences, and community issues. It ensures that all students, regardless of socioeconomic or linguistic background, can see themselves as capable scientists.

Data Collection and Analysis Strategies

The treatment aimed to understand the impact of inquiry-based learning on the quality of student questions. The impact was measured using a variety of instruments designed to collect both quantitative and qualitative data. The data from each instrument was analyzed to understand the impact that inquiry had on student questions.

Data Collection Methods

Using a variety of instruments, both qualitative and quantitative data were collected throughout the action research project (Table 1). At the beginning and end of the unit, the class was given a pre-and post-unit test (Appendix B) and a pre-and post-student survey (Appendix C). Educator Observations were the student artifacts of questions students generated after participating in the phenomenon. Post-Semi-Structured Interviews (Appendix D) were given to a smaller subset of random students (*n*=9) after experiencing the treatment.

Table 1 Data Triangulation Matrix.

	Focus Questions	
Data Collection Instruments	How do Title I students perceive their own growth and development in questioning skills as a result of engaging in inquiry-based learning activities?	How does inquiry-based learning impact the quality of students' questioning skills and depth of content knowledge in Title I science classrooms?
Pre and Post Unit Test		X
Educator Observations	X	X
Post Semi-Structured Interviews	X	X
Pre and Post Student Surveys	X	

Pre and Post Unit Test

The instrument that I used to answer my research question, How does inquiry-based learning impact the quality of students' questioning skills and depth of content knowledge in Title 1 classroom? was the Pre-and-Post Unit Test (Appendix B). The data this instrument measured was quantitative data. Students took a pre-test before the intervention and a post-test after the intervention. After the post-test, I compared the results. This demonstrated whether the inquiry-based learning intervention was effective (Dimitrov & Rumrill, 2003). The goal was to see if the questions students asked in the post-test met the Utah Science 5th grade standard, "ask questions to plan and carry out investigations to identify substances based on patterns of their properties" (Utah State Board of Education, 2024, p. #14). The insights gained from this instrument let me know if the inquiry intervention successfully gave students the strategies to ask questions on a test. The test also measured students' content knowledge of the topic and allowed me to quantify how much knowledge students gained after the treatment.

<u>Educator Observations</u>

To answer both of my focus questions, How does inquiry-based learning impact the quality of students' questioning skills and depth of content knowledge in Title 1 classrooms? and How do Title I students perceive their own growth and development in questioning skills as a result of engaging in inquiry-based learning activities? I used the Educator Observations which were the student artifacts that I collected. The artifacts, including the questions students generated during inquiry-based activities, provided qualitative and quantitative data. I analyzed the questions for emerging themes, categorizing them as either observational, explanatory, systems, or statements. This allowed for a qualitative understanding of how students thought and engaged with the lesson. Additionally, I recorded the frequency of question types, offering quantitative insights into shifts in their questioning skills over time. After the inquiry activity, students developed questions collaboratively with their shoulder partners, giving me a valuable snapshot of their cognitive engagement and classroom experience (Sagor, 2000).

<u>Post Semi-Structured Interviews</u>

I used Post Semi-Structured Interviews (Appendix E) to answer both of my research questions. The interviews were conducted with nine of my class's 14 students and provided qualitative and quantitative data. Interviewing has become one of the most common methods for qualitative research across educational, health, and social sciences (Brinkmann & Kvale, 2018). I used a semi-structured interview style, with a roadmap of questions and the freedom to go off script if necessary (Morgan, 2021). This ensured that the conversation could have a more natural flow and could be flexible in terms of the students' responses. This approach allowed me to gather in-depth insights while maintaining flexibility in the conversation to understand the students' perspectives better.

<u>Pre-and-Post Student Surveys</u>

I used Pre-and-Post Student Surveys (Appendix D) as my final instrument. This answered my research question, How do Title I students perceive their own growth and development in questioning skills as a result of engaging in inquiry-based learning activities? This was a descriptive research design collecting quantitative data. The surveys were used at the beginning of the unit and at the end of the inquiry-based learning intervention to help determine whether students saw significant growth in their learning. The Likert-scale survey aimed to determine students' opinions and perceptions of their learning (Bowen & Bartley, 2014). Surveys allow for a straightforward comparison over time. Since the survey was the same and given before and after the intervention, it produced consistent numerical data, allowing me to analyze the shift in students' perceptions of their questioning skills. Another benefit of using surveys is that they are accessible to various students. Over half of my class is below grade level in reading, so having a survey accessible to all levels of readers makes the data more accurate and reliable.

<u>Qualitative Analysis Strategies</u>

The data analysis technique that I used for my action research project was emergent thematic analysis. The purpose of this technique is to categorize themes that appear in students' questions and organize them into a coding scheme (Mertler, 2020). I used the coding scheme to look at the data and notice patterns as they emerged from students' questions. According to the research (Guest et al., 2012), coding schemes allow data to be refined and aligned to the analysis objective. Data is meant to be read multiple times by the researcher, which is when the themes materialize (Fugard & Potts, 2019). Once I defined my themes, I used Microsoft Excel to color-code my themes to analyze my data further.

The next step was to read students' questions repeatedly until themes and patterns arose (Ignatow & Mihalcea, 2018). The next step was to use the coding scheme I developed from student artifacts and apply the codes to students' questions (Appendix E). After I had coded students' questions, I started to look for patterns and themes in the data. These patterns and themes revealed if inquiry-based learning enabled students to develop testable questions. I created a bar chart with question categories as the x-axis and the frequency of the questions as the y-axis. This showed how many students were asking what types of questions.

Quantitative Analysis Strategies

The data analysis strategy I used for my quantitative research was to generate the mean, median, mode, and standard deviation statistics. The responses from a Likert survey are ordinal-level responses, meaning they can only be calculated as a median and cannot be analyzed with a t-test or ANOVA test (Bowen & Bartley, 2014). This was a suitable approach for my research questions because it was a statistic that revealed student perceptions, which was my research question. I was able to understand what students' perceptions of their growth looked like. Likert surveys are concise and accessible for my students to answer and easy for me to interpret. The data revealed whether inquiry-based learning impacted students' perceived growth in science.

The steps I followed to implement my data analysis included administering the survey after students had finished creating questions based on the inquiry activity. Their responses were counted and quantified since they were on a 1-4 scale. After the scores were counted, I implemented the mean, median, mode, and standard deviation for each item to determine what was typical or standard for my group of students (Mertler, 2020). I demonstrated this data visually through a stacked bar chart, which showed the distribution of responses for each question. The x-axis represented each question, and the y-axis showed the percentage of students for each category. This data showed me how effective the inquiry intervention was in helping students develop their own questions and their perceptions of their growth from before and after the intervention.

CHAPTER FOUR

DATA ANALYSIS: CLAIMS AND EVIDENCE

Academic and Question Quality Growth

Students demonstrated statistically significant growth in content knowledge after the inquiry-based learning intervention. Results from the Inquiry-Based Learning Intervention pre- and post-content tests indicated a medium effect size, with a value of .75 (N=14) based on the standard Cohen *d* Effect Size analysis. The effect size was found by determining the difference in means between the two groups and then dividing by the standard deviation $d=(M_1-M_2)/S$. This effect size difference suggests that there was a medium to large indication that the intervention substantially impacted the students. The effect size works better for a small and diverse class because it considers the change in an individual's score; normalized gain does not consider the class size (Madsen et al., 2016). The effect size values can be considered as relatively low (0.2), which means a subtle difference between the groups, medium (0.5), which is a moderate or noticeable difference, or large (0.8), which is a clear and obvious difference (Goulet-Pelletier & Cousineau, 2018). In addition, I conducted a paired t-test to examine the pre- and post-test content scores for the students and found a highly significant p-value of 0.00055, thus the null hypothesis was rejected, and the analysis supported the alternative hypothesis. The alternative hypothesis was that there would be a difference in students' scores after the inquiry-based learning intervention, and the students demonstrated on average a 22% increase from pre- to post-test, with the highest gain percentage at 57%. Growth was observed for 86% of students, with only 14% maintaining the same score and 0% dropping their score (Figure 1).

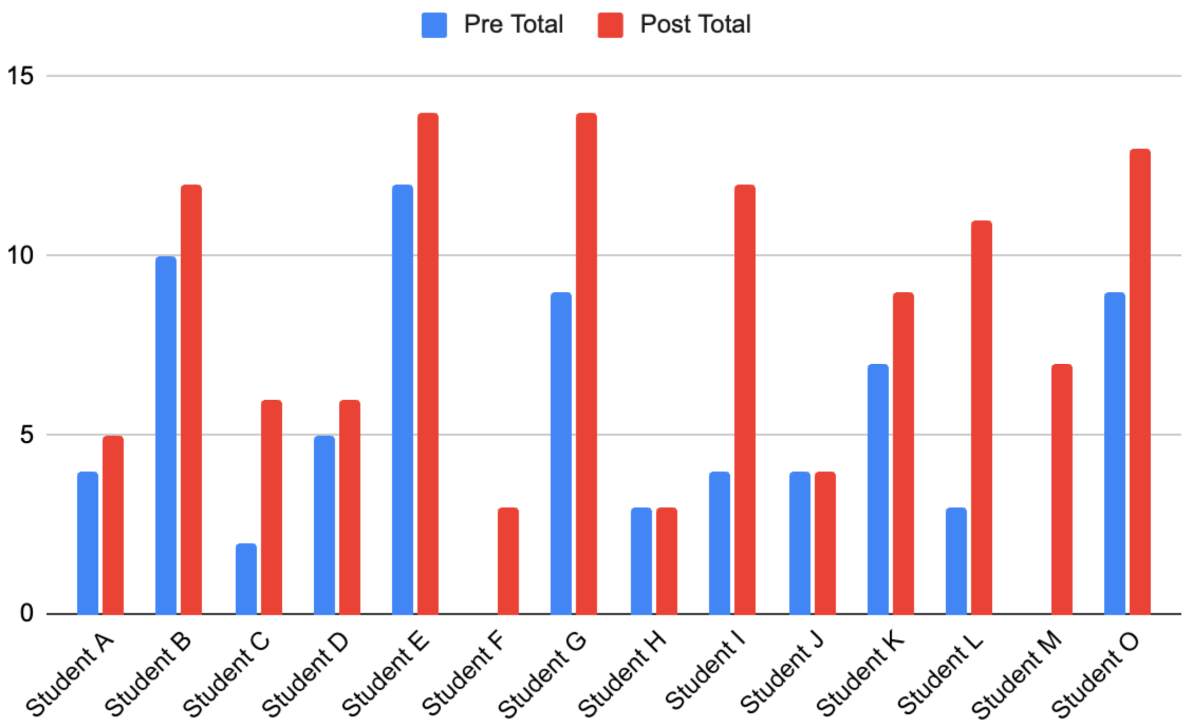

Figure 1. Pre- and post-test scores for inquiry-based learning intervention, (*N*=14).

The Standard Deviation was calculated and depicted as error bars associated with each mean value, and the pre- and post-test scores were compared (Figure 2). The means showed a higher post-test average, and despite the overlap between the Standard Deviation error bars, the paired t-test supported my conclusion that the gains showed a significant trend, though not statistically.

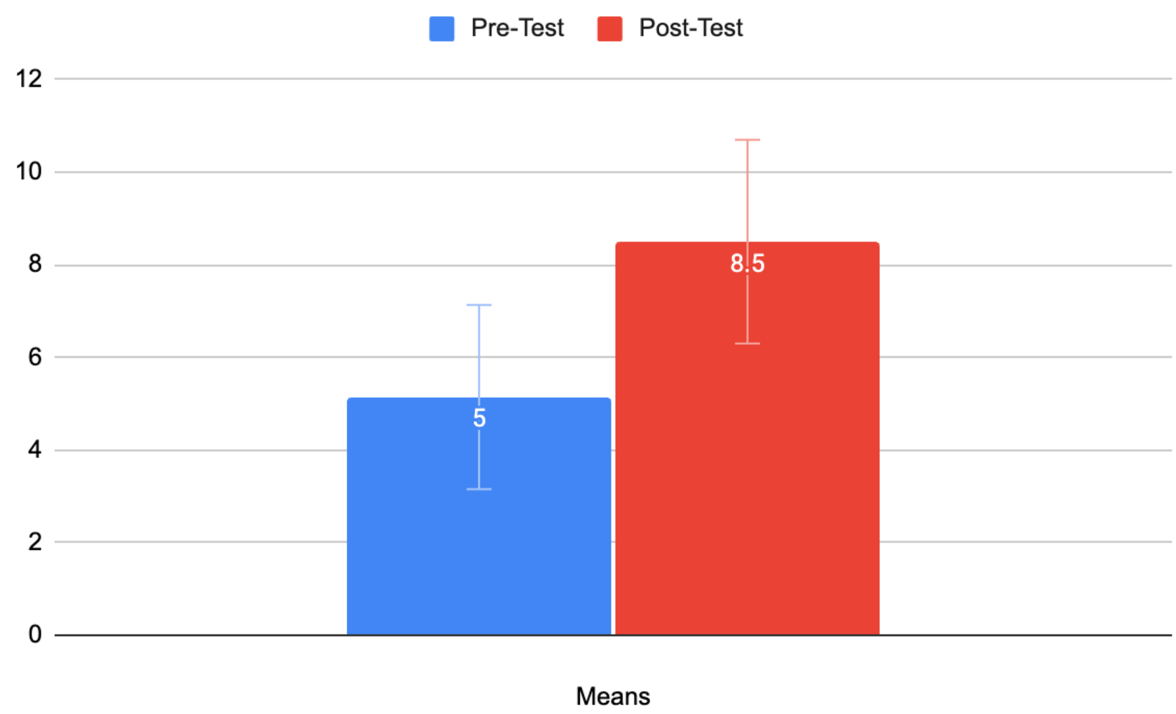

Figure 2. Pre- and post-test mean scores with standard deviation shown as error bars, (N=14).

In the pre- and post-student survey, the strongly agree and agree categories rose 18% for the question, “My questions help me think more deeply about the topic” (Figure 3). One student wrote in their survey that, “it made me feel there was more to learn than just the main topic.” Students expressed how asking questions sparked their curiosity during our interviews. One student said, “If I ask a question, I am going to focus on science to see if there are answers.” Another student mentioned, “(asking questions) makes me more interested, I pay more attention and see the small details.”

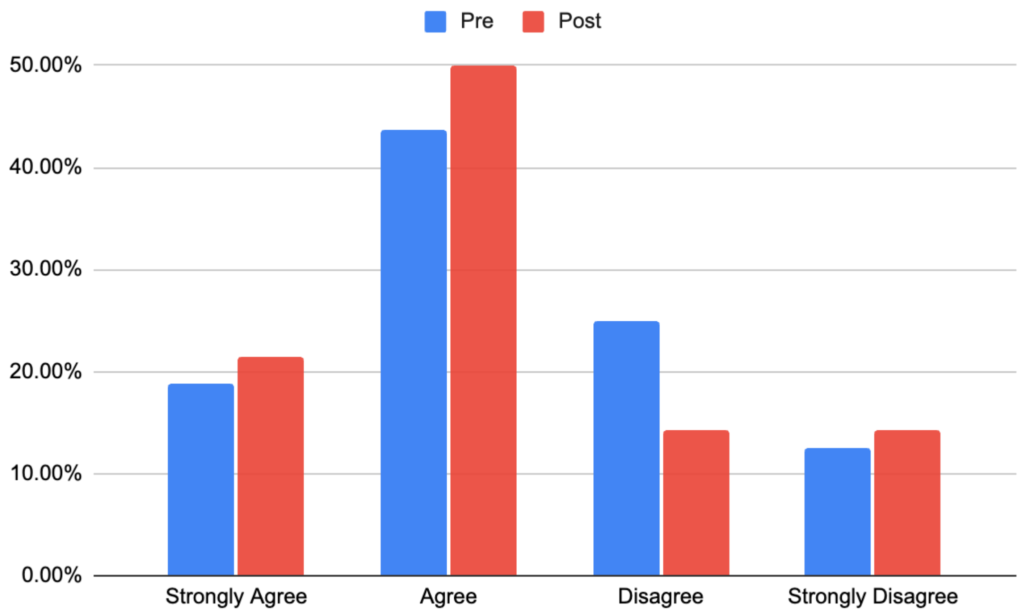

Figure 3. Likert-scale survey. My questions help me think more deeply about the topic, (*N*=14).

For the survey question, “Making my own questions has changed the way I think about learning,” strongly agree/agree rose 14% from the pre- to the post-survey, and strongly disagree dropped to 0% on the post test (Figure 4).

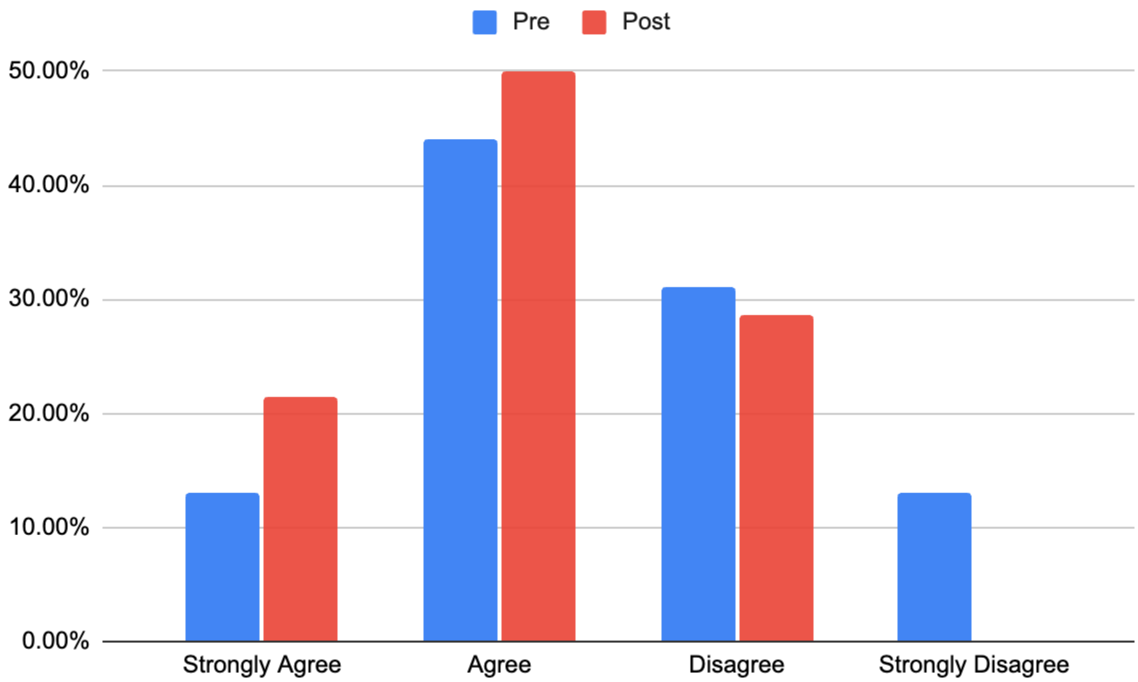

Figure 4. Likert-scale survey. Making my own questions has changed the way I think about learning, (*N*=14).

The inquiry-based learning intervention fostered student curiosity, which deepened cognitive engagement and led to academic growth. As students generated their questions, they became more invested in learning and began thinking more critically about the content. This is reflected in the statistically significant paired t-test gains on the post-test, medium effect size, and student reflections. These responses suggest that students experienced a shift from passive to active learning, where their inquiry drove them to process information on a deeper level. The increased agreement in survey responses supports the conclusion that academic growth was tied to a more meaningful and self-directed learning experience. Inquiry enhanced their knowledge as well as changed how students thought about learning.

Students demonstrated growth in the quality of the questions asked after the inquiry-based learning intervention. When looking at the pre- and post-test student-generated questions, there is a 16% rise in explanatory questions, with a decrease of 21% in observational questions. Systems questions increased by 10% and statements dropped by 4% (Figure 5). Pre-test focused on what students could see and were surface-level questions, "What is the white stuff?" or "Why is one big spot darker than the rest?" It also included statements that articulated what they were observing, "Sometimes the water increased." The post-test revealed more questions in the explanatory or systems categories. The same student who asked the previous question in the pre-test asked this question in the post-test, "Did the water decrease naturally or because of something else?" Other students asked more explanatory questions in the post-test, such as, "Is the shrinking from climate change?" or "How much did the salt level increase?" There were also a few more systems questions, "Did the water turn to a gas so is that how it shrunk?"

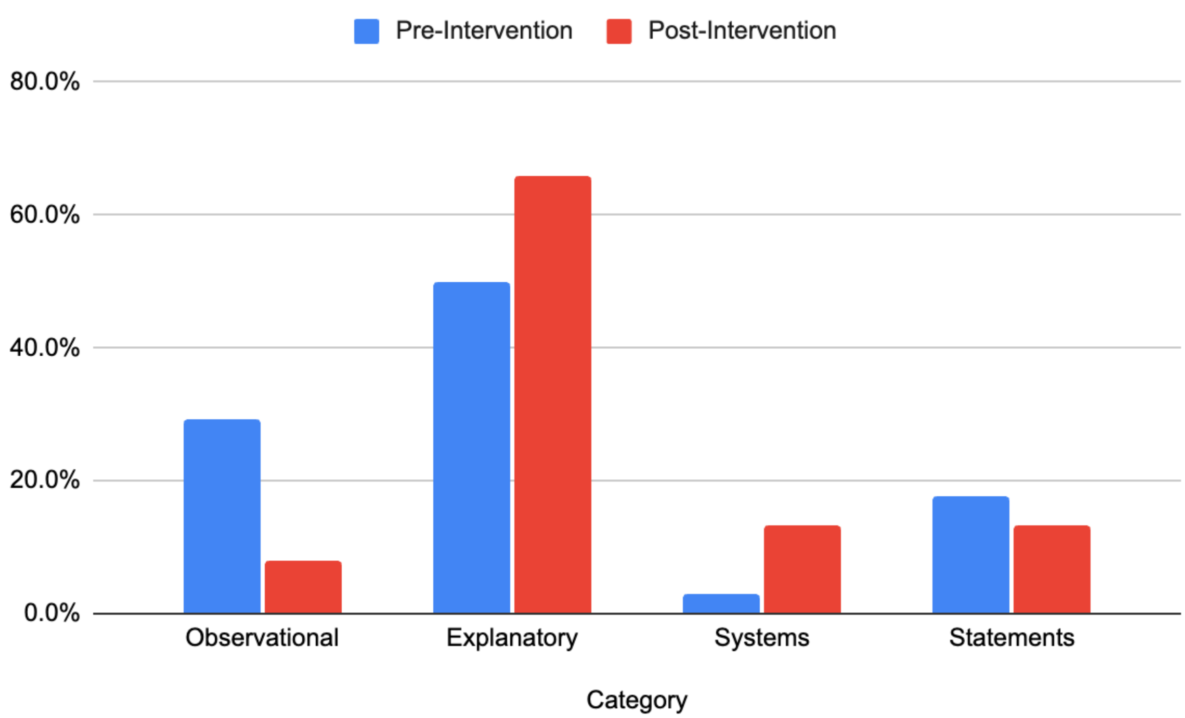

Figure 5. Pre- and post-intervention student-generated questions, (*N*=14).

The survey question, “I know some good tricks for coming up with interesting questions about my work,” showed a modest gain of 8% from pre- to post-survey, with a combined increase of 3% in the strongly agree/agree categories. The number of students who selected the strongly disagree category dropped from 6% to 0%. While the item “I frequently think of my questions while participating in class activities” saw a slight overall decline, the decrease in the strongly disagree category from 6% to 0% suggests a reduction in students who feel disconnected from the questioning process in class (Figure 6).

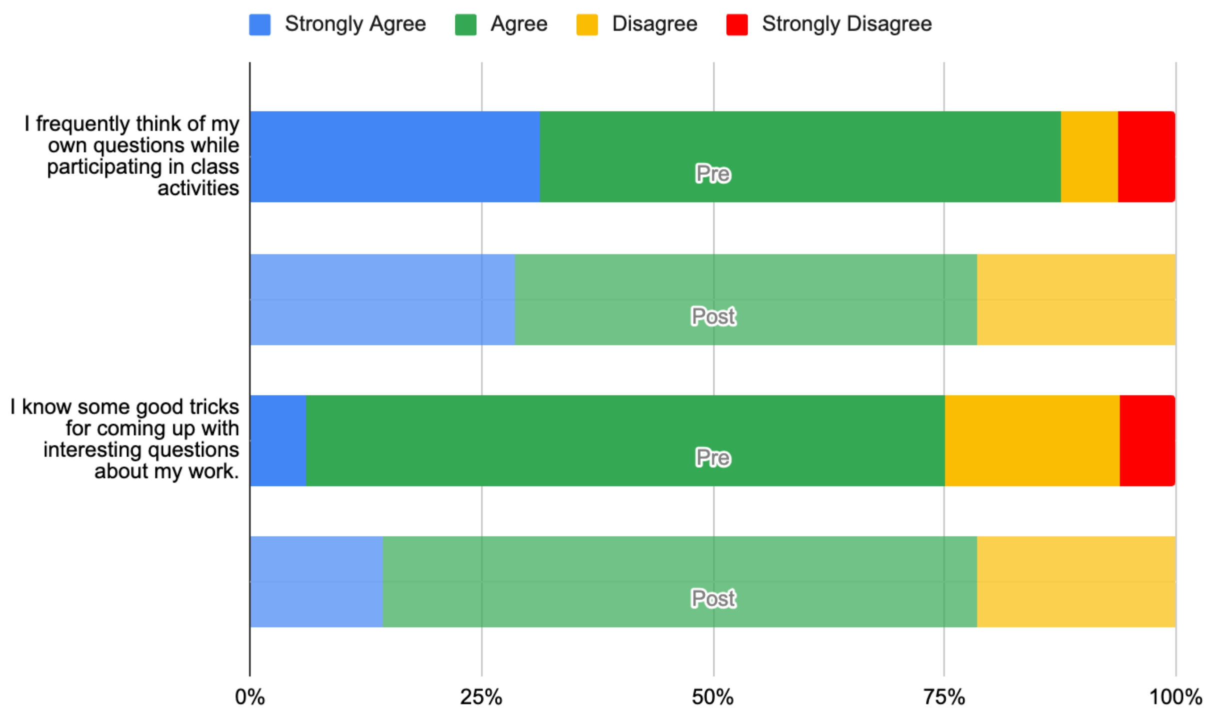

Figure 6. Likert-scale pre- and post-intervention survey data, (N=14).

The shift from observational to explanatory questions suggests meaningful cognitive growth and a deeper engagement with scientific thinking. The increase in explanatory and systems questions indicates that students moved their thinking beyond what they could see and towards understanding relationships within the Great Salt Lake system. They connected the phenomena to a broader scientific topic, such as climate change. The decrease in observational questions suggests that students moved away from surface-level patterns and instead sought to create more complex, investigable inquiries. These changes are reinforced by the responses to the student surveys, which showed that students felt more capable of generating meaningful questions about the phenomena. While not dramatic, the surveys show the students' growing sense of agency. These patterns demonstrate that the inquiry-based intervention effectively shifted students' thinking patterns from passive observers to analytical thinkers.

Confidence, Collaboration, and Engagement

The inquiry-based learning intervention fostered greater confidence, peer collaboration, and a shift in students' perceptions of science as an engaging and accessible subject. The nine students who were interviewed all reported they enjoyed science more this year than in the past and that it was their favorite subject. One student said, "Science is the best time of the day at school." Students also expressed how their views of science have changed over time, "I used to not really like science because I thought it was kind of boring. But when we do activities and talk about it, I kind of like science now." When looking at the pre- and post-test data for these nine students, they demonstrated high post-test gains with a p-value of 0.04. We can reject the null hypothesis and accept the alternative hypothesis that test scores would change after the inquiry-based learning intervention. The combination of increased enjoyment and statistically significant learning gains suggests that the inquiry-based approach deepened their understanding and fostered a more positive learning experience in science.

In the post-survey open responses, there were significantly more positive remarks than negative remarks. Eighty-two percent of students' comments were positive, while only 18% were negative (Figure 7). Positive student comments revolved around learning from their peers, "Because we have different ways of seeing things and sometimes me and my classmates know more background about that thing so we can have new questions," and "When my classmates say a good question I start to think of a good question as well." Negative student comments were about the difficulty of coming up with good questions and not knowing whether the questions were good "sometimes, it is hard to come up with my own questions because when I don't understand the topic I can't think of a good question to ask," and "It was kinda hard because I had to think about if that was a good question or not." In the pre- and post-survey questions, there was an increase of 10% from strongly agree/agree in the category, "My classmate's questions help me think of new ideas for my own questions," with the largest change coming from the strongly agree category at 18% from pre- to post-survey. A slight increase of 3% in the overall score of strongly agree/agree for the category, "I feel comfortable sharing my questions with other students," but a larger increase in the strongly agree category at 16% (Figure 8). This suggests that collaborating with their peers allowed students to improve their questions as they built on each other's ideas.

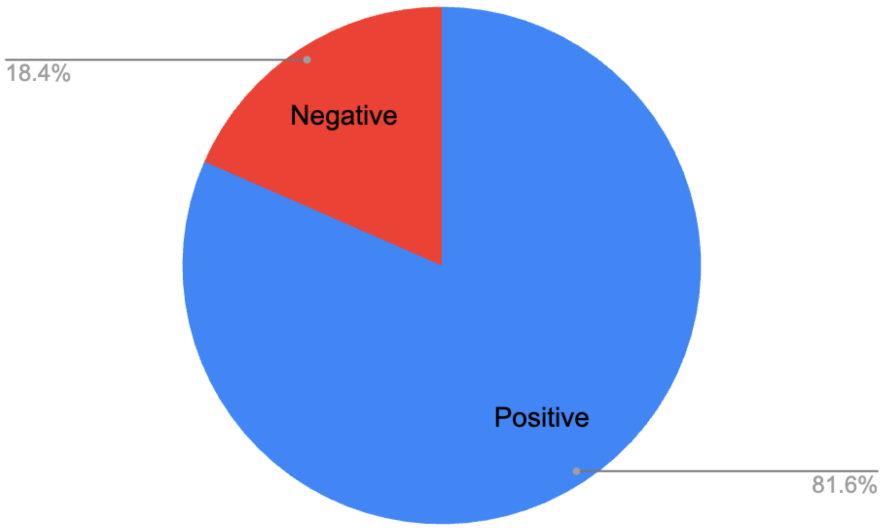

Figure 7. The number of positive vs. negative comments students made during their post-survey open-ended questions, (N=38).

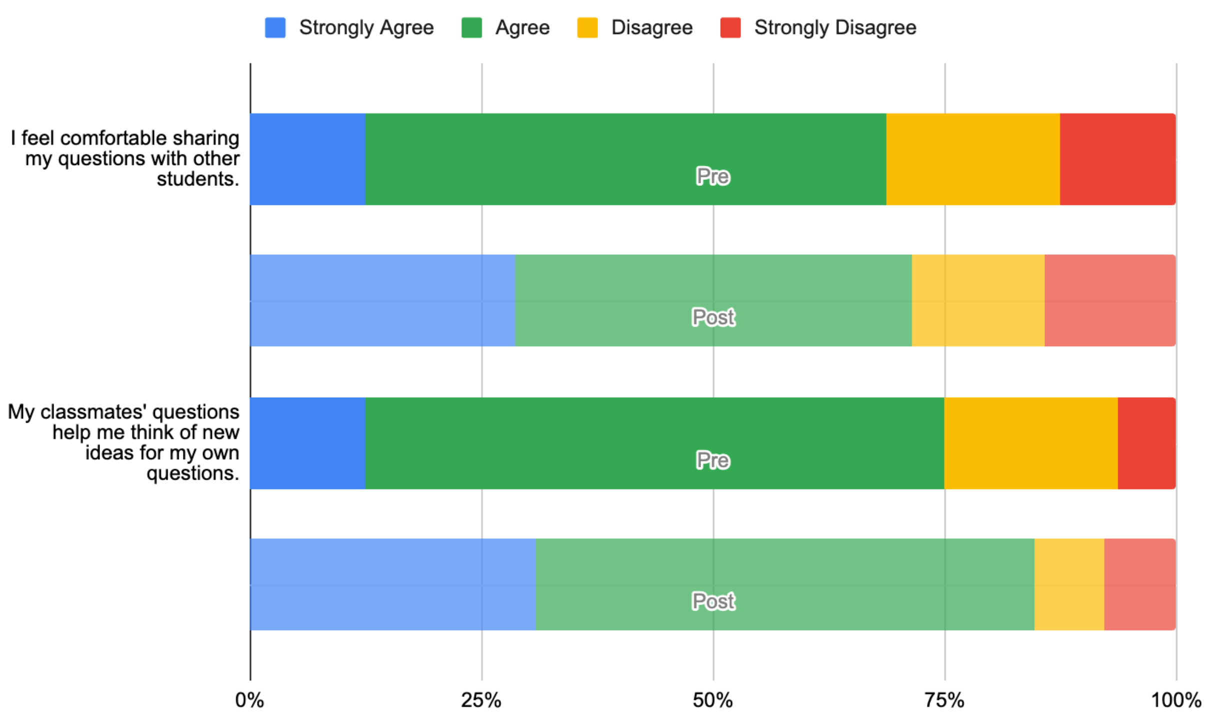

Figure 8. Likert-scale statements and student responses from pre- and post-survey data, (N=14).

Students perceived growth in questioning skills improved following the inquiry-based learning activities. During the one-on-one interviews, students discussed how questioning changed for them throughout the intervention. One student said, “Coming up with my other questions are getting easier. At the beginning of the year, I didn’t really know. But now I know.” Another student said, “Usually, I don’t write questions. But now, since I write questions, I feel like I’ve grown better.” The Likert-scale pre- and post-survey statements also reflected students' perceived growth. For the statement, “I am better at coming up with my own questions now than I was at the beginning of the year,” the strongly agree/agree category rose 15% from pre- to post-survey, and the strongly disagree category dropped from 6% to 0% (Figure 9). A sense of resilience developed from participating in the inquiry activities. One student said, “Like when you mess you, you learn more, and you learn how to not mess up.” There was also a sense of pride from the students as they discussed finding answers to the questions they asked, “I feel proud in that I was able to figure it out myself.” These responses suggest that as students engaged in inquiry-based learning, they became more confident in generating their own questions and developed a sense of ownership in resilience that changed how they see themselves as scientists.

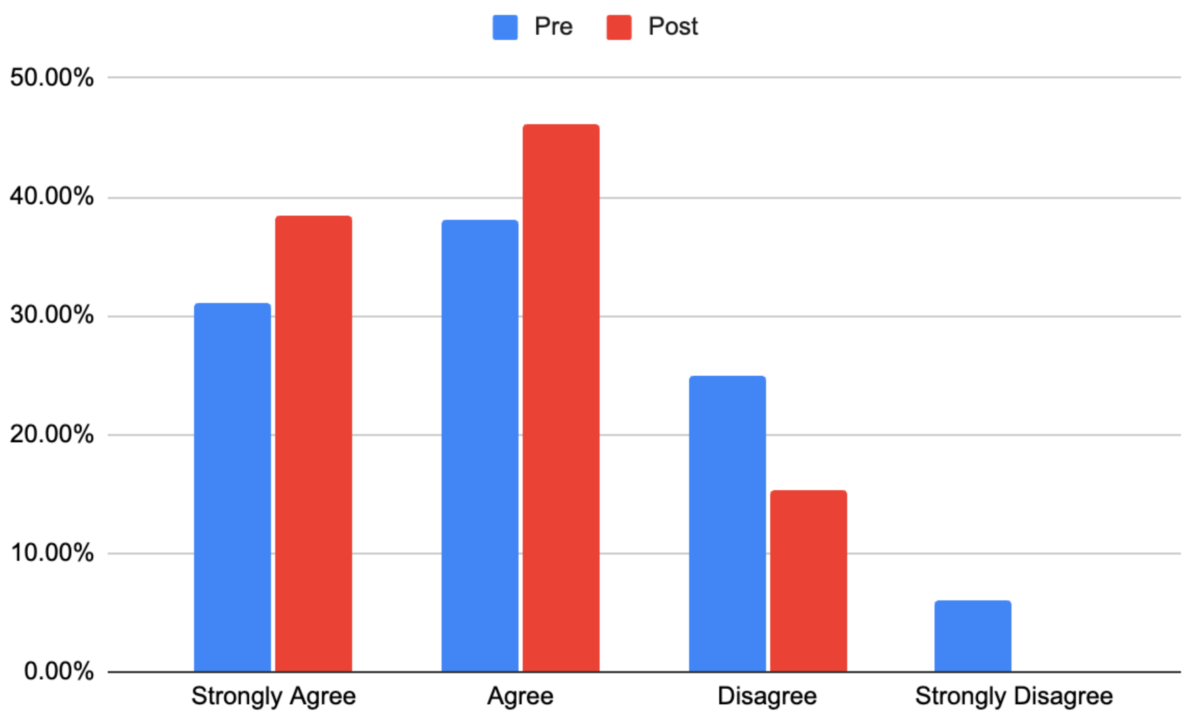

Figure 9. Likert-scale survey statements. I am better at coming up with my questions now than I was at the beginning of the year, (*N*=14).

CHAPTER FIVE

VALUE: REASONING AND REFLECTION

Claims From the Study

This research aimed to determine if the quality of students' questions would increase with the intervention of inquiry-based activities and to measure how students perceived their own growth. The sub-questions were: (a) How do Title 1 students perceive their own growth and development in questioning skills as a result of engaging in inquiry-based learning activities? (b) How does inquiry-based learning impact the quality of students' questioning skills in Title 1 science classrooms? I conducted the action research over four weeks and utilized four inquiry-based learning activities throughout the unit to draw reasonable conclusions from the data collected. The data gathered from a pre- and post-content test, pre- and post-student surveys, educator observations, and student interviews demonstrated higher test scores, growth, engagement, and quality questions from students.

Statistically Significant Growth in Content Knowledge

Students demonstrated statistically significant growth in content knowledge after the inquiry-based learning intervention. The quantitative analysis of the pre-and post-content assessment showed a medium effect size, and the paired t-test proved to be statistically significant. Students' scores increased by 22%, with 86% of students showing growth. Additionally, students' responses to the Likert-scale survey showed that asking questions helped them to think more deeply about the topic and that making their own questions changed the way they felt about learning. Student reflections also supported this growth. These findings indicate that inquiry-based learning improved students' academic performance. Researchers Grier et. al (2008) found that students in urban settings increased their high-stakes standardized scores when using a project-based inquiry science intervention in Detroit Public Schools. By generating their questions, students became more engaged, motivated, and attentive to details, likely contributing to their meaningful gains.

Growth in the Quality of Questions

Students demonstrated growth in the quality of the questions they asked following the inquiry-based learning intervention. Analysis of student-generated questions from pre- to post-content tests showed an increase in explanatory and systems questions and a decrease in observational questions and statements. Students demonstrated a shift from surface-level observation to causal reasoning. Overall, students felt they knew some good tricks for coming up with interesting questions about their work. While there was a slight decrease in students who frequently think of their own questions while participating in class activities, eliminating the strongly disagree item from this Likert-scale item shows that students feel more comfortable asking questions in class. These results indicate that students became more skilled in generating higher-order questions. Researchers Muhamad Dah and Mat Noor (2021) found that when students are provided with a scaffold, such as the QFT, they produce higher-quality questions. The shift from observational to explanatory and systems questions shows an emerging ability to think scientifically and develop questions that can be investigated.

Increased Engagement, Collaboration, and Confidence

The inquiry-based learning intervention fostered greater confidence, peer collaboration, and a positive shift in students' perceptions of science. All the students who were interviewed reported that they enjoyed science more this year than in years past and they expressed a change in how they view learning. These same students also demonstrated statistically significant growth in their content knowledge with a p-value of 0.04 from pre- to post-content tests. Open-ended survey responses echoed these findings, with 82% of responses being positive. Peer collaboration increased and helped students develop better questions throughout the intervention. Interviews revealed that students found themselves more capable of asking questions now than at the beginning of the intervention. The combination of affective and academic outcomes suggests that inquiry-based learning improved students' ability to generate quality questions, enhanced their confidence, resilience, and collaborative learning. According to Chin and Osborne (2008), students who have the opportunity to investigate their questions reported higher levels of motivation, engagement, and reported feeling happy and proud of their work. By engaging in science through their own questions and collaborating with peers, students began to see themselves as more capable learners. This underscores the ability that inquiry-based learning has to develop students into scientists.

Value of the Study and Consideration for Future Research

Inquiry-based learning activities can increase engagement in the classroom, leading to higher test scores and higher enjoyment of science among students. School competes with phones and video games for student engagement. If inquiry can engage students at a high level, then it is worth exploring how to incorporate it more into the curriculum. Shifting the focus of science to come from students' own curiosity and generated questions creates higher levels of investment and promotes deeper-level thinking. After the inquiry intervention, students could generate questions about how and why something happens, instead of making surface-level observational questions.

Future research could include a comparison of two different focus groups. Students in group A could have the inquiry intervention, while students in group B have the standard instruction. The comparison of results from these two groups could strengthen the argument that inquiry-based learning has a positive impact on student learning. Another angle that would be beneficial is to do interventions that could increase student questions in the systems and engineering categories. Systems had a low percentage of questions, and engineering had 0% of the questions in pre- and post-test. It would be helpful to figure out which inquiry activities could lead to questions in those two categories.

Impact of Action Research on the Author

This action research project has impacted my teaching in several ways. I have become more confident in myself as an educator. It has been validating to create a curriculum that I believe in and that students will succeed with, and then have that curriculum verified with data as being effective. This process reflected Mertler's (2020) emphasis on teacher empowerment through iterative, reflective practice. The data I gathered directly informed my instructional shifts and deepened my awareness of student needs. It has also shown me what my students can do. One student told me what they learned after the intervention, and they stated, "Because if I ask a question, you go into more detail, and the details will stay in my head." This showed me that through asking questions, students started to pay attention to new details and were able to remember more about what they learned. Through this research, I have realized that students thrive with a balance of structure and autonomy. I have seen authentic joy and wonder come from my students during the activities, and their connections surprised me. My favorite connection happened during our second inquiry activity. This activity involved the mixture of baking soda and vinegar. Students observed how, when mixed in a closed Ziploc bag, the bag would start to inflate and, in some cases, explode. One student asked, "Baking soda and powder are in bread. Is this why bread rises?" I was impressed by the connection they made between science and cooking. Conducting the interviews was the most rewarding part of the action research project. Rarely do I have the opportunity during the day to meet with each student individually and ask for their opinion about their learning experience. I had students who wanted to be interviewed multiple times. This showed me the power of connection and has inspired me to find ways to pull students one-on-one more often.

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APPENDICES

APPENDIX A

IRB EXEMPTION DOCUMENT

Print Active & Current Protocol Reports

Printed By: Coffey, Lauren

6/12/2025 10:10 AM

Protocol #	Reference #	Version #	Principal Investigator	Author	Protocol Type	Protocol Status	Title	Submission Date	Approval Date	Renewal Date	Expiration Date	Parent Protocol #
2024-1826-EXEMPT	1826	1	Coffey, Lauren	Coffey, Lauren	Original	Approved	The Effects of Inquiry-Based Learning on Student Questioning Skills	12/19/2024	12/19/2024	12/19/2029	12/19/2029	

APPENDIX B

PRE-AND-POST-UNIT TEST

Stimulus

The Great Salt Lake has changed over time. As the water level in the lake has decreased, the water has become saltier. Deposits of salt are left near the shoreline where water has evaporated from the Great Salt Lake.

Figure 1- The Great Salt Lake

This image shows the Great Salt Lake. Image from https://www.britannica.com/place/Great-Salt-Lake

Great Salt Lake Evaporating, Utah - Time Lapse - YouTube - Youtube video showing a time lapse video of evaporation.

After watching the video, what questions do you have about the Great Salt Lake:

1.
2.
3.

Reading 1 - How Salty is It?

The Great Salt Lake is very unique. There are about 30 salt water lakes in the world and the Great Salt Lake is the largest in the western hemisphere. It has the 9th highest salinity in the world. It is also the 4th largest terminal lake in the world. But what does all this mean? And how did this lake get so salty?

A terminal lake means there is no outlet. There are four rivers (Bear, Weber, Ogden, Jordan) flowing into the lake but nothing flows out. This wasn't always the case. Thousands of years ago, the megalake, Lake Bonneville covered most of Utah. It was a freshwater lake with an outlet to the ocean. The lake continued to drop through evaporation, liquid water changing into gas particles and leaving the lake. As it did so, it became saltier and saltier, leaving a “puddle” that is now the Great Salt Lake. Evidence of Lake Bonneville, and its various levels can be seen in prominent shorelines throughout the area.

Another reason the lake is so salty is because of our mountains. Utah's mountains have many minerals and salts in

them. As rainwater and snowmelt run down the mountains, minerals and salts are eroded and eventually end up in the Great Salt Lake. Since the lake is a terminal lake, the only way water can leave is through evaporation, leaving the salt and minerals behind.
Source: https://stateparks.utah.gov/stateparks/wp-content/uploads/sites/26/2015/02/AISPSaltLesson.pdf

Figure 1 - Map of the Great Salt Lake and Incoming Rivers

This image is a map of the Great Salt Lake. Image from
https://commons.wikimedia.org/wiki/File:Great_salt_lake_drainage_map.jpg

Your Task

In the questions that follow, you will develop and use a model to describe that matter is made of particles that are too small to be seen.

Question 1

Based on the Reading 1 article "How Salty is It?" and the Figure 1 map, What are the factors that contribute to the salt levels of the water in the Great Salt Lake? Choose the four factors that contribute to the salt levels.

- Dissolved salts and minerals are carried into the lake through rivers and streams.
- The Great Salt Lake is unique.
- It's a terminal lake which means it doesn't have an outlet.
- The only way water leaves the lake is through evaporation.
- When water evaporates it leaves minerals behind.
- Lake Bonneville covered Utah thousands of years ago.

Question 2

Using the information in Reading 1 and Figure 1, what would happen to the salt particles in this system if the fresh water level increased?

____

____

____

Question 3

Using the information in Reading 1 and Figure 1, what would happen to the salt particles in this system if all the fresh water evaporated and left the lake?

____

____

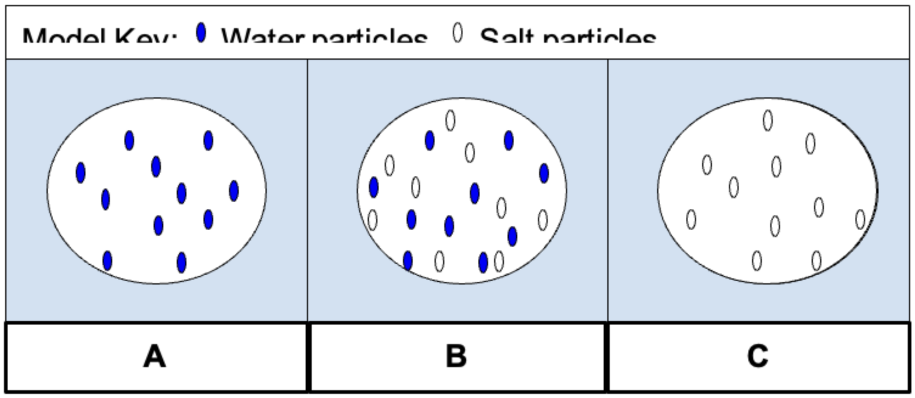
____

____

Question 4

Using the figure below match the letter to the matter that affects the amount of salt that is found in the Great Salt Lake.

Figure 1



This figure shows three different models of water and salt particles.

Model letter	Matter in phenomenon
___	Minerals and salt eroded and ended up in the Great Salt Lake.
___	Water evaporated (turned to gas) on the shoreline showing the salt.
___	Water runoff from rain clouds.

Question 5

Describe how matter composed of tiny particles can account for how the water has become saltier over time in the Great Salt Lake.

APPENDIX C

PRE-AND-POST-STUDENT SURVEY

1. I frequently think of my own questions while participating in class activities.

   Strongly Disagree | Disagree | Agree | Strongly Agree

2. I know some good tricks for coming up with interesting questions about my work.

   Strongly Disagree | Disagree | Agree | Strongly Agree

3. I am better at coming up with my own questions now than I was at the beginning of the year.

   Strongly Disagree | Disagree | Agree | Strongly Agree

4. My questions help me think more deeply about the topic.

   Strongly Disagree | Disagree | Agree | Strongly Agree

5. Coming up with my own questions makes me more interested in what we are learning.

   Strongly Disagree | Disagree | Agree | Strongly Agree

6. I feel comfortable sharing my questions with other students.

   Strongly Disagree | Disagree | Agree | Strongly Agree

7. My classmates' questions help me think of new ideas for my own questions.

   Strongly Disagree | Disagree | Agree | Strongly Agree

8. At the start, it was hard for me to come up with my own questions.

   Strongly Disagree | Disagree | Agree | Strongly Agree

9. Making my own questions has changed the way I think about learning.

   Strongly Disagree | Disagree | Agree | Strongly Agree

APPENDIX D

POST-SEMI-STRUCTURED INTERVIEWS

Reflection on Science Learning and Activities:

1. What kinds of activities or projects have you been working on in science class this year?
2. How do you feel about learning science?

Asking and Improving Questions:

3. On a scale from 1 to 5, with 5 being the highest, how would you rate your ability to ask questions in science before we began doing more hands-on activities? Why?
4. Can you share a question you asked in science that made you feel proud?
5. What's the hardest part about coming up with a good question?

Impact of Questions on Learning:

6. Do you understand science topics better after doing these hands-on activities? How do you know?
7. How do your questions help you learn more about science?
8. How do you feel when you can answer a question you asked during an activity? How does that make you feel about learning?

Looking Forward:

9. Has asking your own questions changed the way you think about science or learning?
10. Do you feel more excited to ask questions in science in the future? Why or why not?
11. How do you think you can get even better at asking questions?

APPENDIX E

QUESTIONS CODEBOOK WITH DEFINITIONS

Code	Definition
Observational	Questions that are formulated using your senses
Explanatory	Questions that are wanting to understand how or why something happens
Systems	Questions that focus on understanding how different parts of a whole interaction and contribute to the overall function of the system or behavior
Engineering	Questions that define a problem and lead to further action
Statements	A sentence that is not phrased as a question (NGSS Lead States, 2013a)