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The Impact of Inquiry-Based Science on Learning Outcomes and Language Development

by

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Thesis Abstract

As the Unites States demographics continue to rapidly change, statistics and trends show that underserved subgroups, such as English Learners, continue to fall behind English-only counterparts in all content areas as measured on several standardized achievement test scores. As this discrepancy in achievement deepens, as does the representation of these subgroups in college and careers areas of Science, Technology, Engineering and Mathematics (STEM). The future of these students and the future of our demographically changing nation depend on the altering of instructional practices to meet the needs of these underserved populations, and all students, while adhering to state academic standards.

Keywords: inquiry science, hands-on learning, language acquisition, English Language Proficiency, content knowledge,

Definitions:

- *Inquiry-based learning*: is a form of active learning that starts by posing questions, problems or scenarios
- *hands-on learning*: is the process of learning through experience, and is more specifically defined as "learning through reflection on doing"
- *second language acquisition*: the process by which people learn a second language. Second-language acquisition is also the scientific discipline devoted to studying that process. The field of second-language acquisition is a subdiscipline of applied linguistics, but also receives research attention from a variety of other disciplines, such as psychology and education.
- *English Language Proficiency*: he ability of an individual to speak or perform in a language.
- *Content knowledge*: generally refers to the facts, concepts, theories, and principles that are taught and learned in specific academic courses, rather than to related skills

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Chapter One: Definition of the Problem

English Language Learners (ELLs) consist of 9.4% of all students in the United States, totaling approximately 4.6 million students (Castellón, et al, 2015): a figure that has more than doubled the past three decades (U.S. Department of Education, 2016). In California alone, a total of 1,140,229 students are designated as English learners, consisting of 20.4% of the total enrollment (CA Dashboard, 2019). The significance of these numbers lies in the persistent gaps in achievement for English learners in comparison to their English-only counterparts as measured by standardized achievement tests and language proficiency assessments. According to California School Dashboard accountability system, English learners scored 94.1 points below the standard, whereas "English-only" students scored 6.5 points above the standard (CA Dashboard, 2019). These ongoing trends of underperformance of our underserved students can no longer be ignored.

With high expectations, rapidly changing demographics and the evolving needs of our student populations, traditional teaching methods have been proven to no longer work for the greater good of our schools. With implementation of new Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS), and the development of English for the rising population of English language learners, our students and teachers are being asked to undertake more than ever before. One ongoing struggle for educators has been to find the time needed to provide quality, relevant instruction while adhering to grade-level standards in all content areas. This in combination with meeting the language needs of all students, has called for a shift in teaching methods and practices. Educators everywhere are wondering how it all can be fit in with the countless responsibilities, ever-changing demographics and rising expectations of teachers and students in response to global pressure. The United States scored an unimpressive 38th out of 71 in reading ability and literacy skills on the cross-national assessment, Programme for International Student Assessment (PISA). This assessment also revealed gaps in other areas showing the US scoring 30th in math, and 19th in science (Desliver, 2017).

Considering the demographics of the nation’s schools, it can be assumed the low achievement scores of the large minority groups may have had an adverse effect on these rankings.

Educational leaders in districts continue to find efficient ways to for teachers to implement valuable instructional practices and learning experiences to engage the minds of students, with the ultimate goals of developing literate and career-ready children. But the question of how all students can benefit from these learning experiences has been at the forefront of the discussion. Many educators believe English proficiency is a prerequisite to concepts in the areas of STEM and even science content instruction and has led to minimal, uninspiring science instructional delivery, and even the exclusion of sub groups from science instruction in an effort to improve language proficiency. The result of these non-inclusive practices has ultimately led to the lack of interest and underrepresentation of English learners in STEM-related fields. The National Science Board contends that the US will soon face a shortage of professionals in STEM related fields. (National Science Foundation [NSF], 2014). With expected growth in the STEM industry and the under-par rankings of all US students, especially our underserved populations, the need to examine the efficiency of science and math implementation is of great importance.

This paper will examine practices that can serve all populations and that can provide quality, meaningful instruction for *all* students to ensure students are being prepared for college and career readiness, while maintaining the goal of improving English proficiency. The practices examined can be incorporated into the everyday classroom with a focus of integration of science, language and inquiry. The research conducted will shine a light on the shifts of the NGSS and how we can support all learners, regardless of native language, on their path not only to English proficiency, but also a career path that could lead into a STEM field.

Purpose of Study

The purpose of this study is to examine learning outcomes of English learners amongst all learners before and after a scientific, exploratory, hands-on guided activity. Learning the needs of our underperforming and/or underserved populations is at utmost importance, as our word faces a global influx of careers in STEM. This research will provide a better understanding of best practices related to STEM content, while adhering to state academic standards and the needs of our lowest achieving subgroups. This study will examine the effect of inquiry-based science instruction practices and will focus on the following two research questions: (1) to what extent does integration of inquiry science affect content understanding for students, specifically for English Learners, and (2) to what extent does inquiry science alter students' perceptions of science content?

Preview Literature

The literature examined in this study highlights important factors that could contribute to the gaps in achievement between English learners and other subgroups, and the subsequent lack of representation of English learners in STEM-related careers. Key areas in this research study include the lack of English learners and US students in general in STEM-related fields globally, the modern challenges educators face with changing population demographics, the definition of inquiry science how it can be used as a driving force for language development, and the responsibility of educators to build students' capacity for a successful future in college and career. Analyzing these areas and issues allows for analysis of these and other key contributing factors for the discrepancy in achievement and the disconnect with English learners and STEM-related fields.

Among the contributing factors that will be examined is the claim of insufficient time for educators to provide English learners adequate English Language Development (ELD) *and* meaningful and relevant scientific experiences, in addition to all other content instruction responsibilities. "The increasing demand for STEM-skilled professionals is a global trend, so diversifying the STEM education-to-career pathway will benefit the global STEM market" (Richards, 2018). Teaching practices must be adapted to the needs of changing demographics in order to provide equitable access to English learners in *all* content areas in order to build the foundational supports for students to pursue paths in science and other STEM fields. The literature reviewed highlights teaching practices involving inquiry science as a common method to drive modern science instruction. To address the challenge of time due to increased demands, this paper will examine the notion that, "students do not need to wait until they learn English in order to engage in scientific thinking and complex scientific content" (Soddart, T., Pinal, A., Latzke, M. Caraday, C., 2002) and that when using inquiry-teaching methods, science can provide a learning environment where collaboration and peer-to-peer talk is a natural part of how students make meaning and develop language. Synthesizing these ideas and forming solutions to the underlying issues, such as finding ways to integrate science and language development, is detrimental in shaping the opportunities and futures of our nation's elementary-aged students. Knowing better methods for integration of science and language skills can address these areas of research and provide much needed foundational skills in both areas.

Preview of Methodology

Work samples from students of all subgroups will be analyzed to measure the impact these experiences have on the overall conceptual understanding of the given scientific topic and for English learners, and indicators of the progress and development of language proficiency. The study will also explore student perceptions about science, and to what extent there is a correlation between these inquiry learning experiences and the confidence and interest levels of students of the given scientific content. Students will be asked to complete a three-question survey, gathering information around student confidence, comfortability and interest levels related to the science content being explored before and after the inquiry science lesson.

The methods for this study will include a sampling of all thirty-two students in a fifth-grade classroom setting with particular emphasis on analysis of the responses of students who have been designated English language learners of varying levels in English proficiency. Qualitative measures include the collection of student writing samples, both before and after an inquiry lesson to assess students' articulation of understanding of the science content in order to gauge the impact of the lesson on the learning targets and performance expectations. The collection of written work will provide evidence of to what extent hands-on, collaborative learning has an impact on students' ability to communicate ideas; which subsequently can enhance and progress language acquisition. A final quantitative measure in the form of pre and post surveys will be used to gauge students' comfortability in communicating ideas, confidence with completing the task and their interest levels in related scientific topics. These key areas of data collection inform this research by providing a better understanding of motivational factors of students when learning about science as well as what kinds of structured instructional practices can create more comprehensive understanding of science topics.

Significance of Study

To ensure we support the English learning students in our schools and create strong foundational skills upon which to build a future in college and in the workplace, current instructional practices need to be reevaluated and restructured. WestEd makes the following conclusion in their research: "The past decade, the infrastructure for supporting science education in California has eroded significantly. As a whole, California needs a new road map for supporting science learning in public schools. Strengthening science education must be a priority" (2011). While this is essential in providing equitable access to all students to support their furthering education and pursuit of careers, especially in the areas of STEM, developing language proficiency is a key element in our students' success as well. The California Department of Education (CDE) suggests that a designated approach to English language development is research-based and is a practice that is encouraged to support gains in this area (CDE, 2018). From close collaboration with teachers, it has been observed that many teachers feel this is an unrealistic demand with the many other responsibilities and expectations. This study is significant in that it explores best practices in response to the everchanging demographics and learning needs of students. It is necessary to examine new methods of instruction, such as inquiry-based science instruction, that could potentially bridge the learning accessibility gaps for English learners by creating valuable, enriching learning experiences, while building aptitude and interest in scientific concepts during formative years when perceptions and foundations are developed. This study is different from other studies in that students will have the opportunity to assess their own understanding and gage the level of comfort they have with the content being introduced. This data is relevant and important when investigating new strategies for instruction of English Learners considering that students will typically speak and participate more when they are comfortable in the learning environment; thus supporting their English development. Knowing types of teaching practices that are supportive of students' confidence and academic discourse is vital in developing English proficiency and closing the gaps of achievement for English learners.

Conclusion

With growing expectations, stagnant or declining progress of English learners and underrepresentation of ELs in STEM fields comes the need for modification of practices to ensure equitable access to content is being provided to all students. The challenge schools are faced with is how to effectively provide instruction in all areas, but especially in the areas of language development and science for this underrepresented group of students. There is need for redistribution of instructional minutes, reorganization of instructional delivery, and the need to examine the impact of the integration of inquiry science, content, and language instruction.

If students are showing considerable growth and language progress from these experiences, and reporting higher confidence and interest levels, leaders in education can begin to encourage their implementation and provide teachers and students the resources needed to do so. Small shifts in best practices such as these can provide foundational support for our English learners and pave pathways for successful careers in STEM-related fields, or any sector of the workforce for that matter. The current literature on these topics will be reviewed for the reader to better understand the basis of this study.

Chapter Two: Literature Review

The ongoing work to support ELLs, along with the implementation of educational initiatives and new content standards have created a notion that there is not enough time or resources to provide quality instruction in all content areas. In a survey of over 5,000 educators in California on the effectiveness and satisfaction of teachers in classrooms with English learners, the predominantly reported challenge of this work includes the lack of time to effectively do so. Educators report the deficient of sufficient time to do everything they need to do and that students lack adequate time to learn everything they need to learn. "Respondents were frustrated that there was not enough time to teach their EL students the regular curriculum, English language development, and to understand and address other students' needs. Some teachers said their students spent much of the day in pull-out programs, which further cut into their classroom time. Others said that they needed to spend small group or individual time with their EL students but that the school day did not allow time for this."

While some school leaders might lead schools in the prioritizing of English Language Development (ELD), school leaders of affluent schools were nearly two times more likely to implement science initiatives in their schools (Dorph et al. 2011, pg. 25). In this study we aim to explore student perceptions about science and to what extent there is a correlation between these inquiry learning experiences and the interest levels of students considering the given scientific content.

Additionally, growing gaps in achievement between ELLs and their counterparts have initiated urgency to develop language proficiency. This gap and subsequent underrepresentation of subgroups in areas of Science Technology Engineering and Mathematics (STEM) fields can be connected to apparent limitations of schools in providing quality instruction in *all* content areas while developing students' English proficiency. How can we address the needs of all students, in all subgroups, in all content areas? That is the growing hurdle educators are faced with, in creating equitable access for all students. These studies highlight a growing body of research that supports the necessity of integration of English Language Development (ELD) with content area concepts. Ultimately, providing such equitable access should bridge the discrepancy of underrepresented populations in STEM fields.

Data from various sources reveal gaps in achievement continue to persist for students from underserved backgrounds. International assessments reveal that the United States “lags behind other developed countries in average mathematics and science literacy scores” (National Science Board, 2017). In response to these unfavorable statistics and trends, the emergence of educational initiatives such as STEM, project-based learning, coding, engineering and several other self-driven learning approaches, have driven professional development and risen to the top of the long list of priorities for educators in the United States. With the notion that English language proficiency is necessary for deep conceptual understanding, it isn’t surprising that implications such as designated ELD time and reading intervention take precedence over science or social studies, both untested in all but two grades in grades K-8. For a lingering amount of time, elementary science experiences were rare and loosely connected to any other experiences in a students’ life.

National Achievement Discrepancies

Data from various sources reveal gaps in achievement continue to persist for students whose first language is not English. The National Assessment for Educational Progress (NAEP) reports that 9% of ELs in grade 4 were proficient or above in reading while 14% were proficient or above in mathematics on the 2017 NAEP. An even lower percentage of ELs were proficient or above in these subjects in grade 8. In comparison with non-ELs, US Department of Education reports that ELs were “far behind the proficiency rates of non-ELs” and that “although EL performance on NAEP mathematics and reading assessments has improved overall since 2000, more recent years have shown little change for ELs and non ELs alike” (2016).

These trends are not only persistent with our nation’s EL population; other international assessments reveal that the United States as a whole “lags behind other developed countries in average mathematics and science literacy scores” (National Science Board, 2017). The 2015 Trends in

International Mathematics and Science Study (TIMSS), found that the United States ranked 10th in 4th grade and 8th grade math, 10th in 4th grade science and 11th in 8th grade science (National Center for Education Statistics, 2015). This indicates that the quality of science instruction for elementary aged students in the U.S. lacks the supports necessary for students to be successful in this content area. Lack of success may also lead to lack of confidence or interest in this content area.

The literature examined show that this trend continues for high school aged students as well. The 2012 Programme for International Student Assessment (PISA), showed that American high-school aged students ranked 26th in math and 21st in science, while leading countries, such as Shanghai-China, ranked first. (Organization for Economic Co-Operating and Development, 2014). It’s important to connect these statistics with the motivational factors that can influence whether or not students show interest in pursuing a career in STEM fields. “Student attitudes toward an academic subject can be thought of as being composed of self-efficacy and expectancy-value beliefs, two important subcomponents of his or her achievement motivation (Eccles & Wigfield, 2002). Self-efficacy is the belief in one’s ability to complete tasks or influence events that have an impact on one’s life (Bandura, 1986), and research conducted by Unifried, Faber, Stanhop, and Wiebel, clains a notion that students are more likely to pursue schooling in STEM fields if they have high self-efficacy in math (Wang, 2013) or science. (Scott & Mallinckrodt, 2005)” It is detrimental for our students’ futures to examine and refine science instructional practices at the elementary level to improve success on standardized achievement tests, improve students’ perceived self-efficacy, and ultimately to prepare them to meet the demands of the global workforce

As many nations strengthen their innovation practices and improve STEM education, the U.S. has been slow to respond. The World Economic Forum ranks the U.S. 47th globally in the quality of its mathematics and science education (Miller & Horrigan, 2014). In response to these discrepant statistics and trends, the emergence of educational initiatives such as STEM, project-based learning, coding, engineering and other student-driven guided shifts in many school districts. Many districts across the

U.S. have made efforts to improve the trajectory of science instruction. New science standards, *the Next Generation Science Standards (NGSS)*, were developed with the aim to support scientific thinking, with built in language supports for all students, but can be used as an integrated approach in English language development as well. These among other efforts have been infused to spark the engagement of science in the elementary years and to instill a love for science at an early age. Shifting teaching strategies and pedagogy is necessary to adhere to the needs of these students and to fulfill the obligation to prepare all students for college, career and life. This shift in pedagogy can likely contribute to EL students' eventual readiness, interest and/or confidence in pursuing a STEM college focus. While there have been gains in creating pathwyas for under-represented groups in science related fields, a considerable achievement gap remains and this gap expands for students whose primary language is one other than English.

The United States is now in an era hyper-focused on STEM fields yet, for many ELs elementary school science experiences can be infrequent or subpar. However, in many school districts with high populations of English learners and other underperforming subpopulations, other action plans for improvement such as English Language Development (ELD) have taken precedence, adding to their eventual unpreparedness and uninterest for a career in a STEM field. Tracing the academic paths of US students from primary to secondary education, the literature suggests we reexamine the quality of our science and STEM programs for students in the US. These trends indicate the U.S. is in dire need of improving the quality of STEM education and ensuring that everyone has access in order to be competitive in the global STEM economy (Miller & Horrigan, 2014).

The Challenge of Time

The growing list of academic demands for the students and teachers in this era in education can be overwhelming, but include essential components for developing students who are ready for the global and ever-changing workforce. Responding to prolonged trends of being outperformed on global assessments and underrepresented in the global workforce, many school districts have initiated efforts to better prepare our students for college, career and global representation. With the push of recent initiatives in the U.S. such as STEM and the implementation of *Next Generation Science Standards* (NGSS), along with teaching leadership skills, computer literacy and digital citizenship, educators are feeling hard-pressed for time to teach it all efficiently and meaningfully. Many these efforts require professional development, fidelity of implementation, and curricular resources for educators and students adding to the time constraints of such a long list of expectations.

Now include the fact that some of these educators also have the difficult task of developing English proficiency for students who are stagnant in progress. In 2019, the California Department of Education (CDE) reports that there were approximately 1.2 million English learners in California public schools for the 2018-2019 school year. The CDE lists two goals towards "close[ing] the achievement gap that separates English learners from their native English-speaking peers." These goals include ensuring that English learners acquire full proficiency in English as rapidly and effectively as possible, and ensure that English learners, within a reasonable period of time, achieve the same rigorous grade-level academic standards that are expected of all students (CDE, 2019).

While many educators understand that designated ELD is research based and necessary in the development of English, they also contend that it limits time that is typically used for science, math enrichment, project-based learning or STEM activities. When standards and expectations are high, time is of the essence for educators in California and around the country. What, then, in our students' academics gets overlooked? For years teachers and even school leaders admit there was a lack of quality science instruction in the elementary school classroom due to growing demands and changing standards. (Dorph, et al., 2011). In low-income schools and/or those with large populations of English learners, the urgency to develop English proficiency has created an additional pressure on teachers and students. Science instruction has been found to be even further excluded in schools and districts with these demographics (Brown & DiRanna, 2012). When surveyed, teachers often claim lack to time, not only to teach but also to prepare for quality lessons, as the driving factors in the neglect of science. In a study from 2011, 92% of elementary teachers surveyed stated that they had only a limited time for science, 67% saw limited time as the major challenge to providing science instruction, and 81% noted that the emphasis on English language arts and math made finding time to teach science difficult. (Dorph, et al., 2011).

The lack of science instruction and experiences will "likely contribute to EL students' eventual preparedness, interest and confidence in pursuing a STEM major" (Gardener, 2017). Creating equitable access to scientific concepts and experiences can shape the attitudes and perceptions of students' during the most formative of years in their education. English language proficiency and low reading performances should no longer dictate the amount of time allotted for other content instruction. If it is the goal of education is to create equitable access to all students in all content areas, there is a need for the redistribution of instructional minutes, reorganization of instructional delivery, and the need to examine the impact of the integration of inquiry science, content, and language instruction.

Acknowledging the possibility that California alone has 1.2 million ELs with limited access to quality and relevant science instruction due to claimed high demands in teaching, could be affecting a significant number of students across the country. Research suggests that the question should shift from *what* content area is being neglected, to *why* any area should be. According to research, neither have to be compromised.

English Language Proficiency as a Prerequisite for Developing Content Knowledge: The Debate

The CDE currently states that ELD instruction should be both designated and integrated to support language acquisition. Traditionally, "the approach to the education of language minority students separates English language development from content instruction because it is assumed that English language proficiency is a prerequisite for subject matter learning" (Stoddart, et. al, 2002). The research indicates a correlation between the integration of inquiry science and language acquisition and concludes that it actually enhances learning in both domains (Soddart et.al, 2002). When teachers provide language structure practice and facilitate discussions around scientific concepts, learners can develop a more complex understanding of these concepts as they explore and discuss while developing language proficiency. This applied and structured integration of language and science has been shown to enhance understanding and retention in both areas. Although the updated framework for English Language Development and central focus for inquiry-based science typically have different lesson objectives, research suggests it is possible to successfully blend science performance expectations with the development of English. "When the blend is successful, science can be an effective platform for English language development providing a familiar and tangible context for students to develop new language (Zwiep, et al., 2013)"

To further support the noted benefits of an integrated model, Larger (2006) and Stoddart et al. (2002) suggest that "language is central not just to English acquisition, but to learning across the content areas." The language of science contains cause-effect, problem-solution, claims-evidence relationships and the use of analogies and models; all of which provide structure to develop English language proficiency. This research has even influenced the development of new standards, as these language and meaning-building methodologies are embedded in the *Cross Cutting Concepts* in the instructional framework of the NGSS. "As crosscutting concepts are encountered repeatedly across academic disciplines, familiar vocabulary can enhance engagement and understanding for English language learners" (National Research Council, 2011). Both of the claims that English Language Proficiency is a prerequisite to content instruction, and the concern for lack of time to teach both science and designated ELD, are invalidated by the findings in the aforementioned studies and ongoing research.

Inquiry Science: A Driving Force for Language Development

A child with limited English actually seeing a vibration of a tuning fork to understand how sound is caused vibration is unarguably more meaningful than cold-reading about the topic in a text. The intrinsic motivation students have to explore, correlates to understanding, interest and relevancy when it comes to learning about scientific concepts. Without hands-on experiences, students can miss out on meaningful discussions around everyday phenomena and real-life concepts. Fostering and developing these skills in our students better prepares students for ever-changing fields and workplaces.

Converging English and scientific literacy methods to facilitate student learning, requires an inquiry-based approach. “Allowing consistent time for science instruction that incorporates ELD instruction along with inquiry science experiences may provide the authentic and purposeful context students need to develop new language without restricting access to science content” (Zwiep, et al., 2013). What, then, *is* inquiry science? Inquiry is a form of exploration that provides students with common experiences around a scientific concept (citation for definition). Additional research by Settlage, et al. (2005), cites the findings of Vygotsky in 1986, by noting that, “the implicit philosophy of this technique was to begin establishing a common set of shared experiences which would in turn contribute to individual understandings of the science concepts.” Rather than regarding student backgrounds and language barriers as a challenge in science instruction, inquiry science allows teachers to use and build on children’s “funds of knowledge” as a resource to standardize and extend science instruction, “thereby reducing the discontinuities between school science and everyday life” (Settlage, 2013). This method of incorporating inquiry science is necessary for classrooms with cultural diversity as it creates shared experiences and equalizes background information of students. Instead of defining terms, students are engaging with investigative phenomena, thus potential misunderstandings due to different life experiences and backgrounds, are reduced. (NGSS.org, 2017).

When you consider the scientific thinking processes involved in the inquiry science, e.g., analyze, describe, cause and effect, observe, summarize, evaluate, you can see that the functions of English can be easily integrated. Science is an ideal context to develop both academic and functional language (Brown, et al., 2012).

Building Aptitude for a Future in STEM for English Learners

Inquiry science and hands-on exploration are vehicles that can drive student competence around communication, language development, and raising interest in relevant and real-life concepts, while building capacity for a successful future in college and/or career. The importance of language development and supporting students' ability to participate in science discussions is an essential element in this preparation. The work of Krashen in 1985 and his notion that "academic language is learned most effectively through meaningful and purposeful communication in academic contexts continues to drive the development and improvement of best practices in content-area instruction." By structuring opportunities for students to communicate, problem solve, argue, discuss, and make meaning, we are nurturing very important 21st century skills and better preparing these students for success in STEM related fields, or any profession for that matter. According to NGSS.org, a goal in the development of the Next Generation Science Standards is to " give local educators the flexibility to design classroom learning experiences that stimulate students' interests in science and prepare them for college, careers, and citizenship" (2017). A classroom lacking these opportunities is at the detriment of the students and the likelihood that they will gain confidence or interest in a STEM-related field. Jobs in this field are not the only positions that require practice and development of communication, critical-thinking, collaboration and creativity skills; or the 4 C's as they are referred to by many in the field.

It's important to note that separate and specific language instruction is still encouraged by the CDE to ensure that we are providing the appropriate language support for ELs. Designated ELD is what the CDE describes as a "protected time during the regular school day when teachers use the CA ELD Standards as the focal standards in ways that build into and from content instruction in order to develop critical English language skills, knowledge and abilities needed for content learning in English" (CDE, 2019).

This paper supports the idea that if these language standards are delivered in tandem with Science content, it will not only increase interest levels of students in the areas of STEM, but also provides the language support and overall engagement needed to develop language proficiency by implementing hands-on, inquiry-driven learning experiences. The CDE English Learner Roadmap describes the necessary shifts of the NGSS as “emphasizing academic uses of language for all students, and student engagement with college- and career-ready curriculum using English and other languages. Taken together, these standards highlight the tightly interconnected nature of developing disciplinary content understandings, analytical practices, and academic uses of language for all students” (CDE, 2019). This amongst other literature sources suggest that this shift means that within our educational system we should begin to move beyond isolating students’ English language skills, and towards a model that simultaneously develops their language and literacy skills in various academic areas. Without an instructional model that supports both literacy and content literacy, we may not be providing the foundational skills or aptitude necessary to enter college and/or career in either area.

Connections to the Literature/Conclusion

There is an urgent need to research and improve methods in supporting the growing population of ELLs in our schools so that they are better represented in the workforce in the areas of STEM. Further study on the topic of confidence in communication in science and its impact on academic achievement is needed to support teachers in the implementation of ELD and science-related instruction. Our future workforce depends on it. This paper will contribute to the growing body of research around the development of language as a combination of ELD, Science language development and the impact an integrated method has on students’ confidence levels in communication. In doing so, the research for this study will focus on the following questions: (1) to what extent does integration of inquiry science affect content understanding for students, specifically for English Learners, and (2) to what extent does inquiry science alter students’ perceptions of science content?

Chapter Three: Methodology

The United States is in an era focused on STEM instruction; however, consistent trends persist showing the underperformance of students who are second language learners in the areas of science and math (Coleman, 2019). As the US's student population continues to diversify, so does the need to alter teaching practices to accommodate diversifying language development needs that persist as well. For many English learners, experiences in these areas and the practicing of the skills needed, are rare and hands-on application of scientific concepts hardly exists in some parts of the country. Achieving equitable access for students in all populations while adhering to content standards, and educational initiatives, for some educators, has been deemed impossible. This and other factors have led to a discrepancy of quality math and science instruction which is evident in the 2015 Trends in International Mathematics and Science Study (TIMSS), which found that the US ranked 10th globally in 4th and 8th grade math, 10th in 4th grade science and 11th in 8th grade science (National Center for Education Statistics, 2015).

This systemic problem involving inequitable access to STEM related, exploratory experiences has in part, led to the growing epidemic of the underrepresentation of second language learners in STEM-related occupational fields. Students whose first language is not English are less likely to pursue an occupation in an area related to science, technology, engineering or mathematics. Perhaps there are not enough opportunities for these students to spark interest or gain confidence in these content areas.

When these students are afforded experiences that foster curiosity and 21st century skills, such as collaboration and critical thinking, interest and inspiration can emerge. Is this what our English learners are missing? This paper will examine the impact of exploratory experiences on second language acquisition and the impact on students' perceptions of scientific concepts. The goal of this study is to examine the effectiveness of hands-on learning experiences in the development of English as well as the development of interest in the area of science in order to better support students' conceptual foundations for which to build a desire to pursue a career in a STEM field. The following research questions will be a driving focus for this study : (1) to what extent does integration of inquiry science affect content understanding for students, specifically for English Learners, and (2) to what extent does inquiry science alter students' perceptions of science content?

The methods for this study will include a sampling of students who have been designated ELs of varying levels in English proficiency. Qualitative measures of student writing samples of students articulating understanding of the science content will also be collected to better measure the overall effectiveness of inquiry science. A final quantitative measure in the form of pre and post surveys will be used to gauge the interest levels around the scientific content topics to provide a better understanding of motivational factors of students when learning about science.

Design

The design of this research was a mixed-methods approach. Qualitative measures were used to analyze student work samples, gauging their understanding of scientific concepts before and after an inquiry/exploratory experience. Students were first instructed to watch a video and read a short passage on Mixtures and Solutions, after which they provided a model of their understanding and a response to the performance task. Conclusions about student comprehension of the scientific concepts addressed in this lesson were measured against concrete exemplars demonstrating a deep understanding of the content. Additionally, a rubric designed to measure students' ability to articulate understanding through means of models and diagrams will be used. This method for the articulation of scientific concepts is highlighted as one of the Scientific Practices of NGSS. These student samples provided information to gain a sense of students' thoughts, perceptions and experiences. Guidelines were provided for students; including an expected number of vocabulary words and a detailed explanation of the expected task. This method was used to delineate the analysis of content understanding from the analysis of language acquisition to determine if language proficiency level had an impact on conceptual understanding.

A quantitative measure was used to gauge students' perceptions about the content delivered before and after the inquiry science experience. The purpose of this was to determine to what extent student interest levels change before and after exploratory experiences. A likert-type scale was presented to the participants in a web-based format. Items that were measured included students' comfortability in discussing the scientific topic, the confidence level of students in interpreting the concepts learned, and an overall interest level of the scientific topic. The three-question survey was conducted after the initial reading passage was read but before the inquiry science lesson activity. Each level of the rating system had clarifiers, or indicators, and the researcher provided several explanations and examples, and answered any clarifying questions to ensure validation and accuracy of the students' responses.

This mixed method approach focuses on collecting, analyzing and mixing both quantitative and qualitative data in a single study. John Creswell, known for his work with mixed methods research, notes that using these methods in combination "provides a better understanding of research problems than either approach alone" (Creswell, 2011).

Participants

The participants for this study included all English learners of various English Language Proficiency (ELP) levels from a 5th grade, self-contained, general education grade class. Of the thirty-two students in this class, there are a total of 16 students categorized as English Learners; including 4 students in the *Emerging* level, 8 students in the *Expanding* level, and 4 in the *Bridging* level of ELP as measured by the English Language Proficiency Assessments for California (ELPAC). Of these students two are considered *newcomers*, or students who have been in the U.S. 12 months or less and are at the Emerging level in learning English as measured on the ELPAC, and six are considered "Long-Term English Learners" (LTELs), meaning they have received instruction in English for over three years, but have not made adequate progress towards proficiency in English and are "stuck" in the expanding or bridging levels. This data was significant for this study because of the persistent trends of these students underperforming in comparison to their other subgroups. Work samples will be collected from all students as to gauge the efficacy of the lesson overall and in order to have comparable samples of various academic levels and language abilities.

This particular class of students was chosen as it represented the demographic makeup of the school as a whole. 50% of the class are English learners, closely mirroring the 40% EL make up of the school. While seventeen out of the thirty-two students are males, this closely resembles the school's gender make up of 62% male, 48% female. Students with IEPs also participated in this study. Having participants with a wide variety of abilities allows for a more representative cross-section of the school's demographics.

This process by which the researcher collected work samples and responses to survey questions was safeguarded by allowing student participants to opt out of the process altogether.
Students participants with IEPs or other designated accommodations or supports were offered the same supports as they would for any similar assignment and or activity. All thirty-two students in the class individually decided to participate in the study.

Setting

This study was conducted at a TK-6th grade school in a rural community in southern California at Williams Elementary School (WES). The school was built in 1997 and is the newest of eight schools in the small district. The school is situated on rolling hills and from the elevated athletic field, the Pacific Ocean can be seen. The campus is fully handicapped accessible and contains twenty-nine classrooms. WES includes an athletic field house, 2 playgrounds, a large blacktop area including basketball, four-square courts and a track. The campus includes a spacious Multipurpose room and library. All students in grades 3-6 have 1:1 chromebooks and the entire school is equipped with high-speed wifi.

According to the California school dashboard, for the 2018-2019 school year the enrollment at the school site was 539 students. The population at WES maintains a diverse group of students including 70% Hispanic, 24% White, 2% African American, 1% Filipino, 1% Native Hawaiian or

Pacific Islander, 0.6% Asian, and 0.2% American Indian or Alaska Native. Of these student, 77.4% are categorized as socioeconomically disadvantaged, while 40.6% are English learners and 1.1% foster youth.

The town in which WES resides consists of about 48,000 people. Demographics of the town's population is 50% White, 36% Hispanic, 2.2% African American, 0.2% American Indian and Alaska Native, 3.1% Asian, and 1.7% people identifying as two or more races. The median age of residents is 41 years old, while 85.1% have earned a high school diploma and 28.3% have earned a bachelor's degree or higher. The demographics of the faculty, including certificated, classified and support staff, at WES somewhat represents the demographics of the student population; with the exception of the gender statistical differences; considering WES has only one permanent certificated staff member who is a male. The cultural and political climate of the school is largely unknown, but staff and faculty describe the setting of the school as warm, welcoming and a safe place to work and collaborate.

This setting was conducive for this study in that the demographic and gender make ups of the classroom of participants were similar to those described in the problem statement. The basis for this research centers around understanding what best practices are most supportive of students who are English learners and/or socioeconomically disadvantaged; as these students have barriers that their English-only and non-socioeconomically disadvantaged counterparts do not endure. Understanding how to serve the needs of these subgroups is necessary in preparing *all* students for college and career and the possibility for a future in a STEM-related field.

Instruments

The quantitative measure in place was a survey gathering data on students' perceptions of the scientific content and comfortability and confidence in their articulation of ideas. It was important for this data to be collected because it can support the notion that by providing inquiry science experiences, we can spark interest and enhance learning about scientific topics; therefore providing the foundational conceptual and language skills needed on a pathway to a profession in an area of STEM. So often delivery of these difficult concepts can be lacking in resources needed for students to grasp enough understanding of a topic to spark any interest at all. Science instruction should be a catalyst for student interest in these areas, not a limiting factor or deterrent. This survey will gather evidence to support or refute this claim. (See figure 3.1)

Figure 3.1 *Researcher Created Survey*

How to Separate a Mixture

(BEFORE the Lab)

* Required

(1) How comfortable are you explaining your answer to the focus question with a partner for 30 seconds?*

1-Not at all 2-A little comfortable 3-I could discuss for about 15 seconds 4-Fairly comfortable 5-I could describe the process very well and use all the vocabulary words

	1	2	3	4	5	
Not at all comfortable	O	O	O	O	O	Very comfortable - I could use each vocabulary word confidently

(2) How well do you understand the task you are being asked to complete about mixtures?*

1	2	3	4	5
O	O	O	O	O

(3) How are you interested in knowing more about Mixtures and Solut ions?*

1-Not at all 2-A little interested 3-I'm in the middle 4-It's pretty interesting 5- Yes! I want to be a chemist when I grow up!

	1	2	3	4	5	
Not at all	O	O	O	O	O	Yes, I'd like to be a chemist when I grow up!

SUBMIT

By conducting qualitative data analysis on this topic of language acquisition, the researcher was provided with a "greater emphasis on holistic description—that is, description in thick, rich detail—of the phenomenon, setting, or topic of interest" (Mertler & Charles, 2011, pg. 192). The scientific inquiry process that was chosen for this activity also measured a specific function of language. Having a measure to measure this function of language before and after an inquiry science experience provides the researcher with a basis for which to support or refute the intended research topic of the impact of inquiry science on language acquisition. Having a positive impact could mean continued research on best practices for integration of the two. By collecting written responses that allow for modeling to convey ideas, provides differentiation needed to adequately assess learning.

The written task included the following performance task prompt: *List the steps and draw a model to describe how to separate a mixture of gravel, power, salt and steel.* The focus task was written on the board and referenced throughout the lesson series. The task was also provided on a label to be placed in the students' journals. This allowed for consistent legibility of the task and minimize misunderstandings of the task itself. The researcher made copies of the written samples first after the reading task, and again to collect evidence of their modified and enhanced models and explanations. The NGSS and National Science and Teaching Association (NSTA) suggest that the use of models "aid in the development of questions and explanations, to generate data that can be used to make predictions, and to communicate ideas to others." The rationale for including the use of modeling as the assessment tool is that it allows for a level of differentiated scaffolding that could help all learners better articulate ideas. This method is conducive for not only English learners, but all learners of all language abilities and levels, in that the models are intended and expected to be evaluated and refined throughout the learning sequence.

The participants were provided embedded opportunities to revise or redevelop their models and they gained understanding of the task and content. Duschl and Grandy (2013) emphasize “[the] importance that models and modeling, visual representations, knowledge exchange mechanisms and peer interactions have in the refinement of knowledge” and highlight this instrument as path breaking in the use of models in inquiry teaching.

A rubric was used to guide the score analysis for each participants’ written work as well as their visual descriptions/models of their understanding. A rubric was obtained

Procedures

The process for this research study mimics the integration that is suggested as necessary in order to support the learning needs of language learners while adhering to all content standards. The functions of language are vital for students to practice when learning a language. For this reason, having the students communicate information, which is a function of language, about the sequential order of a process was chosen as the exercise for this study. Specifically, the process for which a mixture of various materials can be separated. This topic is related to the overarching concept of states of matter, and properties of various materials. The students would be provided a text explaining both the process to separate this mixture, as well as additional information about the properties of the materials. The classroom teacher had not previously introduced this topic in any way, nor the materials referenced in the reading passage to be read by students.

The students were introduced to the learning task in detail before reading the passage so they were aware of what they were expected to do with the text. The task was displayed on the board, and students were given a label with the task to stick on their papers to reference throughout their writing time. The task was for students to list the steps and draw a model to describe how to separate a mixture of gravel, powder, salt, water and magnetite. As a learning support, the students were provided the materials that are referenced in the text in labeled plastic bags for students to see, but not touch. These materials included: gravel, powder, salt, a screen, funnel, and filter paper. These materials were fixed on the board near the learning prompt for students to view throughout the lesson series. It is common for teachers to bring in realia to serve as a reference and support of language learners' vocabulary development. They were also reminded of words that support the explanation of the sequential order of a process, i.e. *first, next, then, last and finally.* This learning scaffold was provided to ensure that English learners would not be hung up on on the function of language, and be able to focus on the task of explaining the process as explained in the text.

After a thorough explanation of the task and expectations, student subjects were then provided a grade-level reading passage that explained the process of separating mixtures and solutions; specifically, a mixture of gravel, powder, salt and water. The students had fifteen minutes to read and interact with the passage as many times as they could to support the completion of the learning task. It is important to note that the digital forum through which the text was provided to students provided several learning scaffolds, such as reading aloud and highlighting the text for the students which they accessed on their individual chromebooks. So regardless of reading level, all students had access to the information and were able to use a highlight tool to note important ideas, stop the text and relisten to any portion as many times needed, and zoom in to images relating to the text. The text was two pages in total, but students were directed to focus on the first two introductory paragraphs for the specific information needed to complete the learning task. The additional text was relevant to the topic, but would only lend more detailed information about the materials in the process, and not the process itself.

Students were given a total of 25 minutes to read the text and complete the writing task. During this time, the classroom teacher and researcher scanned the room for students that needed more guidance in relation to the task itself. They were also able to reference the vocabulary and realia throughout this work time. As students completed the task, their work samples were collected to be analyzed and measured by the measurement tools and to be compared with post-inquiry-lesson data.

At this point in the lesson series, the students participated in a three-question likert-scale survey to gauge their understanding of the task, their confidence levels in explaining their responses to the task, and their overall interest levels of the content being explored. The researcher made sure the students understood what the questions were asking, and answered any clarifying questions the students had before they completed the survey. The classroom teacher was present in support of the ELs, specifically the newcomers, who needed further translation of the questions in order to accurately provide responses.

Students returned from a lunch break and went to the school's STEM Lab to engage in a hands-on, inquiry science lesson led by the researcher After observing the physical properties of the materials the students were then prompted to combine the materials to create the mixture they read about prior to coming to the lab. The students discussed in their groups, the process for which they could separate the materials; recalling information from the text. After making their plan, the students physically carried out their plan to see if they could successfully separate the mixture. No new instruction related to the content went on during this time. Nor was any follow up instruction or discussion conducted after the students' experience in the STEM Lab to ensure that the learning experience was as exploratory and student-driven as possible.

Students were then provided with the opportunity to add to their existing models and explanations, or to start over; whichever process will help students better articulate their ideas and support their completion of the task. The students were given the same twenty-five minutes they were given to complete the task the first time. They also had the original text and their initial models and explanations to reference while completing the task. The researcher and classroom teacher did not provide any feedback or additional teaching of the content at this time. Students completed the task individually with no interaction or discussion with classmates.

Students' final written samples were collected and scored with the same rubric. Both the classroom teacher and the researcher will conduct analysis of the samples individually, and then collaboratively to ensure an accurate and valid measure of student work. All thirty-two students participated in the survey for a second time to collect their perceptions of the content and the task after participating in the inquiry lesson.

The researcher was in insider in this study because she was also the lesson instructor. This allowed for the anecdotal collection of observational data of students' overt perceptions throughout the lesson series. This also allowed for consistent use of content vocabulary and guidance in the task itself and the use of the same instructional strategies before, during and after the inquiry lesson.

Analysis

The analysis of student work samples collected will be reviewed by both the researcher and the teacher participant using the rubric. The primary foci of the qualitative analysis of student work samples will be (1) students' ability to complete the performance task per the selected rubric, and (2) the students' perception of science content, including their comfortability in expressing their responses orally to their peers and teacher.

Mertler and Charles (2011) suggest using triangulation as a practice to ensure the trustworthiness of data. The use of multiple data sources, multiple data collection methods and multiple analysts of work samples to support the ultimate findings from the study (Mertler & Charles, pg. 199). This method of member checking will involve include the teacher participant in the sharing and analyzing of the data sources to validate the accurate representation of the participants and their ideas (Mertler & Charles, pg. 200). Quantitative analysis of the pre and post interest surveys provided a “snapshot” of students’ interest levels and perceptions of the scientific topics presented throughout the lesson series. The change in interest and perception level will determine if implementing inquiry science activities is a beneficial practice in .

Conclusion

English learners are in need of teaching strategies that are supportive of English development, while being provided meaningful content instruction. The growing list of demands on both teachers and students have created a discrepancy in such experiences for many ELs in the country. This study tests the strategy of incorporating inquiry science to provide context for the content, provide an equitable level of access for all students, and provide a hands-on approach to language development; all of which support the foundational skills needed to pursue a future career in a STEM field. Without such experiences, the path to these careers can be stunted. In order to spark the interest of all students while supporting language development and college and career-related skills, we must alter teaching practices and provide hands-on experiences that they may not otherwise have the opportunity. This paper will examine the impact of inquiry science has on the perceptions of students and their understanding of the task and subject matter.

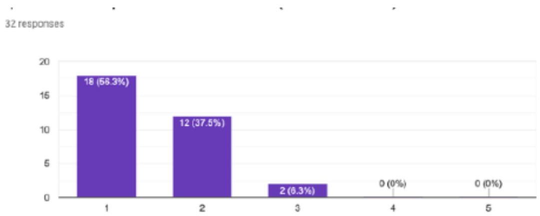
Chapter Four: Data Analysis

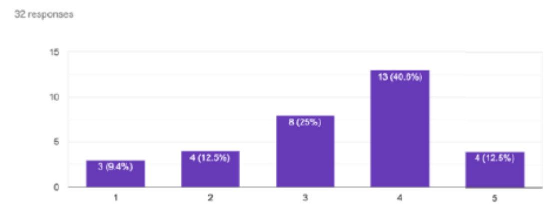
As the student populations and language needs in the US continue to diversify, the trend of a lack of quality instruction in math and science continues to persist. The disconnect lies with the response to the language needs of these students, while omitting important elements of scientific and math exploration. The research conducted addressed this problem by demonstrating how language learners can benefit from hands-on, inquiry experiences in science and how these experiences shape their perceptions and confidence levels about scientific topics. Greater understanding and confidence levels in these topics can positively impact and even guide students into career paths. This chapter will present the findings of the research conducted, describe the analysis of the data collected, and interpret the findings as related to the research questions.

Data Presentation

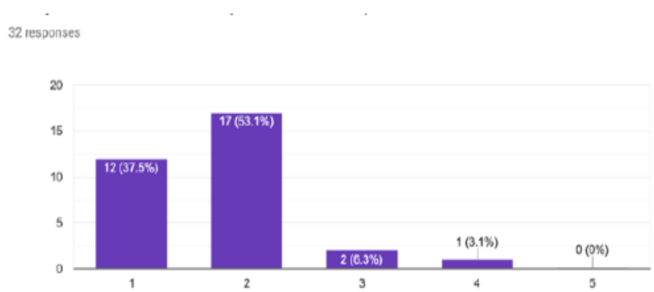
The student samples collected reveal there is a significant correlation between hands-on learning experiences and students' overall understanding of the task and confidence in communicating their ideas. Students' perception and confidence level with the task increased significantly after the inquiry science lab as measured by the likert scale survey. In addition, students demonstrated having a higher interest in the content after completing the task in an exploratory manner, as compared to after just having read a passage about the topic. Explicit findings from the survey reveal the significance and necessity of hands-on learning experiences and their effects on students' perceptions and capabilities around the learning of the content.

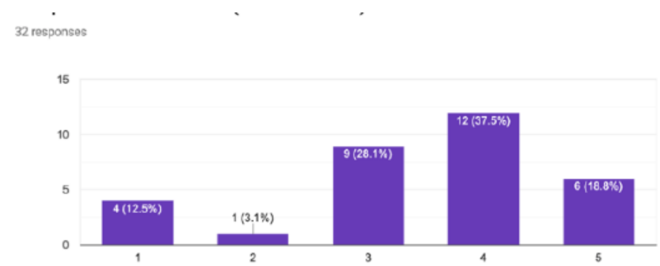
Before Inquiry Lab	*After* Inquiry Lab
(1) How comfortable are you explaining your response to the task with a partner for 30 seconds or longer?	(1) How comfortable are you explaining your response to the task with a partner for 30 seconds or longer?



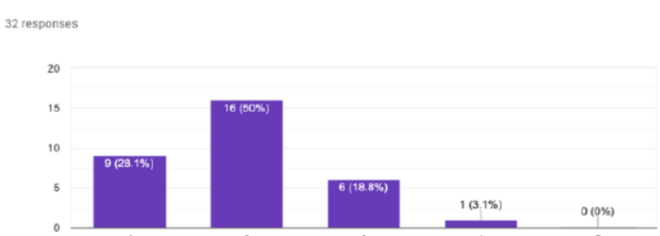


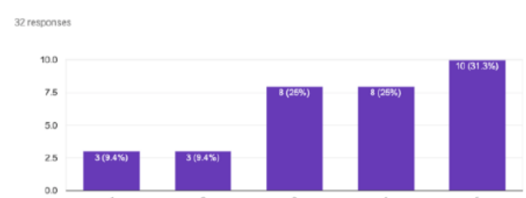
Before Inquiry Lab	*After* Inquiry Lab
(1)-Not at all (2)-A little comfortable (3)- I could discuss for about 15 seconds (4)-Fairly comfortable (5)-I could describe the process very well and use all the vocabulary words	(1)-Not at all (2)-A little comfortable (3)- I could discuss for about 15 seconds (4)-Fairly comfortable (5)-I could describe the process very well and use all the vocabulary words
(2) How well do you understand the task you are being asked to complete about mixtures and solutions?	(2) How well do you understand the task you are being asked to complete about mixtures and solutions?





Before Inquiry Lab	*After* Inquiry Lab
(3) How are interested in knowing more about mixtures and solutions?	(3) How are interested in knowing more about mixtures and solutions?





Before Inquiry Lab	*After* Inquiry Lab
(1)-Not at all (2)- A little interested (3)-I'm in the middle (4)-It's pretty interesting (5)- Yes! I want to be a chemist when I grow up	(1)-Not at all (2)- A little interested (3)-I'm in the middle (4)-It's pretty interesting (5)- Yes! I want to be a chemist when I grow up

Figure 4.1 *Before and After Inquiry Lab*

Data Analysis

The following analyses were formed from the responses to the three survey questions presented to the thirty-two participants. This portion of the research sought to grasp a better understanding for how students perceive the subject matter content before and after hands-on, inquiry-based, exploratory activity. The following analyses are grouped by the questions and responses to the survey:

<u>Question #1</u>

Student participants were asked to rate their comfortability in communicating their responses to the task after reading the passage and before the inquiry lab. Before the hands-on lab experience, 18 out of thirty-two students reported having no confidence explaining their task/solution to the task to a partner after having read the 2-page passage. 94% of students rated themselves as having no or "very little" confidence in communicating their response to a partner. 0 students reported having a high level of confidence explaining their answer to the task including the usage of all vocabulary words. Twenty-nine out of thirty-two, or 91%, of the student participants reported having a higher comfortability level after actually *doing* the task as opposed to just having read about it. 41% of students increased by at least one point, while 13% of all students increased to a "level 5" on the scale; rating themselves as having a high level of confidence in their explanation and usage of content vocabulary words.

<u>Question #2</u>

Students were asked to rate their overall understanding of the performance expectation after reading the passage and before and after the inquiry lab. 0 students had full understanding of the task they were being asked to complete before participating in the inquiry lab. 91% of the student participants reported as having no or little understanding of task itself before the hands-on lesson. 88% of all students reported gaining understanding of what they were being asked to complete after experiencing the task through hands-on manner as opposed to just reading about it. 84% rated themselves as significantly more aware of the task after the hands-on lesson in comparison to 1% before the hands-on lesson. Through the analysis of this question, it is revealed that students demonstrated a deeper understanding of the task itself.

Question #3:

Students were asked to rate their interest levels on the content addressed before and after the inquiry lab. 78% of participants reported having little to no interest in the content before the hands-on lab lesson. 0 students reported having a high-level interest and only 1 student showed moderate interest on the topic of the content after reading the passage and before participating in the inquiry lab. The students' interest levels increased significantly after the hands-on lab. After the collaborative hands-on investigation, 81% of students reported as having a moderate to severe interest level in the content after the inquiry lesson. Only 1% of responses revealed still having no to little interest on the topic after the hands-on lesson.

The student writing samples were measured with a rubric assessing the students' ability to communicate information with models and explanations. Using this measure, thirty out of thirty-two, or 94% students' scores increased by an average of six points per the rubric. Students showed particular growth in the *Explaining* area of the rubric which measures students' ability to communicate to an intended audience about how the system, in this case a filtering system, works and functions and how their designs served to solve a problem. Students not only showed a more complex and concrete understanding of the system, but also of the task itself. These findings correlated to students' responses to the survey in that 88% of students reported understanding what they were actually being asked to do after having participated in the process themselves.

Students were less aware of what they were supposed to do with the text as opposed to after the hands-on lesson. Many students resulted in just copying text or images from the text rather than adhering to the task. Students were able to articulate the process in a more sequential and authentic manner after experiencing the hands-on lesson. 100% of the student participants chose to recreate their model and response to the task after having experienced the hands-on lesson as they felt they could better complete task by doing so; even though they were directed to simply *revise* their models. This analysis also correlates with their responses to the survey question asking them to rate their understanding of the task. The complexity of the student writing samples along with the increased capability to organize their responses sequentially were significantly more sophisticated after participating in the process rather than simply reading the passage. The presence of sequential-order words and phrases indicated that hand-on experiences allow for more thorough explanations and organization of content.

These analyses of the student samples were also cross-examined by the classroom teacher who was present for all steps of the lesson series, but did not participate in the instruction or direction of the lesson series. Including the classroom teacher helped calibrate the data and This method allowed triangulation of the data and was in efforts to increase reliability and validity of the findings. The analysis of the student responses to the survey questions and the scoring of the student-samples were concurred by the classroom teacher.

Interpretations

By looking at the data collected before and after the inquiry science lesson, it is easily observed that the students were able to complete the task to a higher degree of understanding in both the area of content, as well as understanding of the task itself. When students were given the same task before and after a hands-on, inquiry science lesson, their articulation of their understanding as measured by their response to the performance task prompt, went up by an average of 3.7 points per student; with the highest gain being 8 points. Students were able to use content vocabulary deeper meaning after having used and manipulated the materials. The procedure students were being tasked with completing and writing about involved the sequential ordering of a series of tasks using various materials. Having a hands-on experience with these materials and the physical completion of the task allowed students to have a broader knowledge base about the properties of the materials and were therefore able to make more meaning out of what they were being asked to do. Students also demonstrated gains in their ability to use transition and sequential order after completing the task and not simply just reading about it. ___ % of students increase at least one point out of 3 points as measured against the California Common Core State Writing Standard W.5.3.C. Applying practice of applicable writing skills after having participated in a hands-on activity allowed students to demonstrated better usage of transitional words and phrases. If interpreted even further, intentional practice of the functions of language in tandem with these scientific, explorations can also serve as a language support towards students' proficiency in English.

Quantitative analysis of the survey questions students answered before and after the hands-on lesson revealed significant increase in both the areas of level of comfort with the content, the task itself as well as student engagement/interest levels. This can be interpreted to the idea that hands-on, inquiry-based science activity provides background information needed to better comprehend both the content concepts and the performance task and criteria. Students engaging in the content rather than just reading about or watching resources allows to level the playing field in terms of background knowledge. Finding deeper meaning through exploratory experiences have shown to support students' articulation of ideas and comprehension scientific concepts. Many of English learners and socioeconomically-disadvantaged students lack the resources to engage in such activities. By offering these resources to students, we are providing more equitable access to the curriculum and content standards and cultivating confidence in the formative years of their scientific identity.

Altering students' perceptions of science content during these years can shape their paths students take towards college and career in positive ways. Twenty-nine out of thirty-two students reported at least a one-point increase in interest of the topic of Mixtures and Solutions after having a one-hour laboratory experience engaging with the content and materials. If we can spark the interest and curiosity in such a significant manner in just one classroom and in just one content area, the impact of this teaching strategy can be significant if infused and improved upon with more practice and professional development for teachers. The future of the United States' STEM workforce depends on the improvement of our science education. Using research-based strategies to improve students' comprehension and confidence levels is a vital step towards paving stronger pathways that can lead to a successful career in a STEM field for all students.

Summary/Conclusion

The conclusion that can be made after analyzing the various collected sets of data reveal that students significantly benefit from scientific hands-on, inquiry science experiences. Students demonstrated an increase in content knowledge understanding, as well as understanding of the task itself. These findings were not only limited to English learners, but all learners.

These findings can influence educational practices when designing units of study in all content areas. Traditional practices that may include solely the use of text to convey information can be viewed as not meeting the intrinsic learning needs of students. Participating in these hands-on experiences has shown to increase motivation, interest and ability comprehend and complete the performance expectation.

With a new trajectory of lesson design, educators and students can benefit from these findings by eliciting more student participation and interest, thus, providing the foundational skills and motivation needed for students to advance on a path towards a career in science, or other areas of STEM. Implementing these hands-on experiences can minimize frustration levels in these content areas, as well as allow for more authentic learning experiences that increase retention, participation and improve the overall learning experiences for *all* subgroups of students.

As educators, we have the ability to form students' perceptions of learning about science by the manner in which we design learning experiences for our students. The power in this statement lies in the future of students' career paths and the level to which they rely on foundational experiences. By altering teaching practices and cultivating interest and motivation in scientific concepts, we are essentially forming lasting perceptions of students and their learning. In doing so, we are building capacity for future careers in science doing our part to contribute to the future of our scientific society.

Chapter Five: Recommendations

With declining and/or stagnant academic achievement scores for one of our nation's largest and fastest growing subpopulations, coupled with the fact that the US lags globally, we need to reexamine our delivery of content starting at the elementary school level. Traditional methods of instruction have been proven to not work with our changing demographics, therefore we must adhere to the needs of our students by providing meaningful and relevant science instruction that can lay the groundwork for a possible pathway to a career in a STEM field. The declining statistics showing the US does not currently compete in the global STEM field. Combining methods of English language development and science instruction and making content more accessible to students whose first language is not English might be a step in the right direction considering the increase in population of this subgroup in the past few decades. This chapter will summarize the findings, interpretations, educational implications, limitations, and potential future research directions for this topic of study.

Finding Summary

Students' scores in articulation of content ideas and modeling improved by an average of 3.4 points per student on a fifteen-point scale. This indicates that hands-on, inquiry science provides students with the necessary experiences for a deeper dive in conceptual meaning. Reading about a given topic limits our students who may not be at grade level reading ability. Limiting these students is essentially denying them from access to the content. Providing hands-on experiences levels the playing field for students who are socioeconomically disadvantaged and/or whose first language is not English. Students actually seeing a vibration are able to make much more meaning of the word than reading the definition and viewing a picture.

Finding Interpretation

The student participants in this study showed significant gains in their written articulation of ideas after partaking in a hands-on lesson mirroring a reading passage ready prior to their inquiry experience. Having only read a passage, students were limited in accessible prior knowledge if the students were not familiar with the materials involved in the lesson. Having tangible artifacts for students to manipulate and for which student scan conduct their on explorations rather than make meaning from someone else's written words was vital in their understanding of the task and the science concept involved in the lesson. The students were able to revisit the text and respond to the performance task with greater ease and confidence.

After reading the passage in the first phase of the lesson series, students observably struggled to respond to the performance task prompt. Although directly related to the reading passage, students struggled to connect the text to the performance task. After conducting their own experiment directly related to the reading passage and the performance task, students observably and reportedly demonstrated more understanding and confidence with the task and articulation of such. Students use of vocabulary and connectedness of ideas was much more apparent after utilizing the materials in an exploratory fashion.

The findings of this research based on the research questions: (1) to what extent does integration of inquiry science affect content understanding for students, specifically for English Learners, and (2) to what extent does inquiry science alter students' perceptions of science content?

Findings in Context

From the deep analysis of student work before and after a hands-on lesson, I first-had saw how the students learning was impacted from their experience. From the anecdotal observations I gathered, students' frustration levels were at much lower levels when reading a text heavy in content and in academic and scientific vocabulary after having participated in a collaborative, hands on lesson. From this I learned that we can't always assume students have the background information needed to participate in a lesson and or discussion. When we consider the language levels, learning needs and cultural backgrounds of our students, we must provide them with experiences that "level the playing field" and provide common context for which students can build upon.

I was also able to observe students' perceptions of science completely change before and after hands-on lesson revolving around the same content. From observing this research in action, I was able to see much more meaning and depth of context hands-on lessons can afford *all* students. The focus of the research was on students whose first language is not English, however what I gained an understanding that hands-on, inquiry science is not only beneficial for students' understanding, it is absolutely necessary for students to grasp scientific concepts at the depth measured on standardized academic assessments. Not only did the student participants express more comfortability in their expression of understanding of the lesson and reading, they also demonstrated more engagement with the topic itself. The reading did not spark nearly as much engagement as did the hands-on lesson regarding the same exact materials and procedures. Knowing this will help me in the development of future units of study. Without hands on science, I have learned that students cannot make full meaning of text. Because students are testing solely through text, providing them these resources is vital in developing foundations of science in the formative elementary school years.

Something else that was very evident during this lesson series is that hands-on inquiry science does not require explicit instruction of vocabulary. Manipulation of the materials themselves provides students a better method of retention of the meaning of the word. Students were able to use the content and academic vocabulary with deeper meaning after engaging in the hands-on lesson. It also provides more context for discussion. Even if students aren't able to providing you a working definition of a word or process, they are able to participate in discussions more so after using the materials than just having read about them. Furthermore, students were able to use and articulate their understanding of the vocabulary in their written responses. My interpretation of this observation is that hands-on, inquiry science will support academic growth in reading and writing; especially when integrated engaging and scientific text.

Perhaps the most predominant concept I have learned during this research study is that students love science. They love *doing* science. Science cannot be taught through traditional "stand and deliver" methods. I feel we are robbing students of true learning if we are not providing these experiences for the future of our nation. I have learned that without these experiences, students cannot build a foundation of scientific knowledge without hands-0on, meaning science experiences.

Recommendations

Based on what I have learned, I recommend that educators strive to incorporate these hands on, inquiry science lessons for their students in an integrated approach throughout units of study. Not only do these experiences provide a basis for understanding for English learners, but also students from low-socioeconomic backgrounds. Educators of schools with demographics high in these populations should be looking for ways to incorporate hands-on, collaborative, discussion-rich experiences to use as background information when teaching reading standards.

I would also recommend incorporating and fostering 21st century skills into these lessons, such as creativity, collaboration, critical thinking and collaboration. Fostering these skills sets students up for success in college and career. Even if they do not pursue a career in STEM, these skills will surely help student build a repertoire of experiences that can support their participating in today's demanding workforce

As for recommendations for best practices in education research, I would recommend researching alternate methods for the assessment of student conceptual knowledge of scientific concepts. Our students' ability to read should not dictate their ability to understand science. Science is everywhere and in every language. I would recommend applying better methods of assessment revolving around hands-on lessons. Finding better resources and methods to assess students' learning whose first language is not English is also something that could warrant more research.

Limitations

If there was more time to be devoted to this research, I would have conducted more trials for which inquiry science could be measured against traditional teaching methods. I would want to measure these claims with all grade levels and content that is typically believed to be developmentally too high for students of certain grade levels. If more time was allotted for this research, I would have conducted several trials measuring the impact of hands-on, collaborative experiences better prepares our students for a future in our global workforce. I would have also conducted filmed, elaborate interviews with each student to grasp a better understanding for how lessons and activities in a STEM Lab setting, for example, can affect the learning outcomes from the students' perspective. This would also allow an alternate mode of articulation for students that have trouble communicating on paper.

Future Direction

If the integration of English language development can be enhanced through means of inquiry science, further research to support this claim could be extended by testing the same methods with students who are acquiring English, but in an immersion setting. For example, many districts in California and other parts of the United States have begun dual immersion programs in which students acquire a second language in tandem with regular English instruction. Because English and Mathematics are tested subjects in grades 3-8, many immersion programs opt to teach Science during Spanish instructional minutes. Validity of these findings could be measured by assessing the Spanish acquisition by English only students participating in a dual immersion program. If such an analysis can reveal the same results as the present study, inquiry science can be the driving force for the acquisition of *any* second language.

Conclusion

Although building language capacity is only one facet in paving the path for a successful future in a STEM field, or in any field nonetheless, it can have an expansive impact on students' interest in scientific topics, and confidence in communication of their thoughts and findings. These skills have proven to be necessary in most if not all workplaces. Providing experiences that foster these skills is essential in providing students with the tools they need, academically and socially, will essentially and ultimately prepare our nation for better representation in careers in STEM and the ever changing, and ever-expanding global workforce.

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APPENDIX A *Data Table*

Student # / Initials	**Performance Task** (out of 15) **BEFORE** Inquiry Lab	**Performance Task** (out of 15) **AFTER** Inquiry Lab	**Writing Skill** (*W5.3.C) out of 3 **BEFORE** Inquiry Lab	**Writing Skill** (*W5.3.C) out of 3 **AFTER** Inquiry Lab	**Writing Skill** (*W5.3.C) out of 3 **BEFORE** Inquiry Lab	**Writing Skill** (*W5.2.D) out of 3 **AFTER** Inquiry Lab
1 DA	6	10	2	2	1	3
2 SA	4	10	2	2	2	2
3 EB	8	13	1	2	1	3
4 AB	4	9	2	2	1	2
5 KB	10	13	2	3	2	3
6 JB	5	8	1	2	1	2
7 EC	5	10	2	2	1	2
8 AG	8	10	2	2	2	3
9 KG	10	12	2	2	2	3
10 OG	2	6	1	2	1	2
11 SG	8	13	2	3	2	3
12 YG	10	13	2	3	2	3
13 AH	10	14	2	3	2	3
14 CI	11	14	2	3	3	3
15 SJ	11	13	3	3	2	3
16 NM	5	8	2	2	1	2
17 KM	8	11	2	2	1	2
18 BN	4	12	2	2	1	3
19 RO	6	10	1	2	1	2
20 AP	8	11	2	2	1	2
21 VQ	6	9	2	2	1	2
22 RR	1	1	1	1	1	1
23 JR	6	8	1	2	1	2
24 JR	12	15	2	3	2	3
25 GS	8	10	2	2	2	3
26 MS	8	12	2	3	2	3
27 SV	9	13	2	3	2	3
28 JV	8	11	2	2	1	3
29 CV	7	9	1	2	1	2
30 RV	8	11	2	2	2	2
31 JW	7	10	2	2	2	2

Student # / Initials	**Performance Task** (out of 15) **BEFORE** Inquiry Lab	**Performance Task** (out of 15) **AFTER** Inquiry Lab	**Writing Skill** (*W5.3.C) out of 3 **BEFORE** Inquiry Lab	**Writing Skill** (*W5.3.C) out of 3 **AFTER** Inquiry Lab	**Writing Skill** (*W5.3.C) out of 3 **BEFORE** Inquiry Lab	**Writing Skill** (*W5.2.D) out of 3 **AFTER** Inquiry Lab
32 JY	10	12	2	3	2	3

*(W5.3.C) Use of transitional words
*(W5.2.D) Use of domain-specific language

APPENDIX B

Developing and using models: Teacher Rubric

Criterion	**Description of level**	**No evidence** **0**	**Limited evidence** **1-2**	**Clear evidence** **3-5**
Representative: Does the model accurately reflect the aspects of the natural world being investigated or of the designed world being tested?	The model accurately represents the interactions and relationships among the parts of the system being investigated, or among the elements of the solution being proposed.			
Explanatory: Does the model serve to clarify the system, mechanism, or design solution being proposed?	The model clearly communicates to the intended audience how a system functions, why a phenomenon occurs, or how the student's design will solve a problem.			
Aware of limitations: Does the student understand what predictions or conclusions are appropriate to draw from the model?	The student is able to identify and describe the limitations of the model.			
Responsive to evidence: Does the student know how to revise the model in the face of new evidence or test data?	The model reflects revision and refinement based on evidence from testing, or about the phenomenon under investigation.			
Writing Write informative/explanatory texts to examine a topic and convey ideas and information clearly.	CCSS.ELA-LITERACY.W.5.3.C Student uses a variety of transitional words, phrases, and clauses to manage the sequence of events.			
Writing Write informative/explanatory texts to examine a topic and convey ideas and information clearly.	CCSS.ELA-LITERACY.W.5.2.D Use precise language and domain-specific vocabulary to inform about or explain the topic.			
		No evidence **0**	**Limited evidence** **1-2**	**Clear evidence** **3-5**