INQUIRY-BASED LEARNING: PERCEPTIONS, USE, AND BARRIERS FOR 6-12 SCIENCE TEACHERS

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ABSTRACT

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There are many reasons students fail to achieve in STEM related fields post high school. For example, students may spend too much time receiving teacher centered lessons that focus primarily on vocabulary building and concept recognition. These lessons may not necessarily promote understanding or encourage students to learn other skills than memorization and vocabulary. Studies have shown that high school teachers are faced with the challenge of presenting students with a significant amount of information in a short period of time to prepare students for standardized state assessment exams. One possible solution is to implement inquiry-based learning (IBL) to enhance student understanding of STEM subjects and provide students with the skills necessary to succeed before graduating high school. This mixed methods study examined teacher perceptions to IBL, how teacher intent to incorporate IBL into daily lessons affected IBL, and teacher perceived barriers to the implementation of IBL. Quantitative analysis was conducted by analyzing the teacher responses to a modified version of the PRIMAS survey, while qualitative data were obtained from semi-structured interviews. The findings of this study indicated teachers have a positive perception of the principals of IBL and that the intent to implement IBL was correlated to its use in teachers' daily lessons. The major barriers to IBL implementation were found to be teacher's belief in student abilities, along with the time constraints, both the time it takes to conduct an inquiry lesson and the time limits placed on them in order to teach the state mandated and school directed curriculum. The teachers perceived barriers were the same regardless of the amount of IBL in daily lessons. This implies that it is teacher intent, and not the perceived barriers that truly limit IBL as a major teaching methodology in the science classroom.

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CHAPTER I:

INTRODUCTION

Inquiry-based learning (IBL) is considered to be an essential component of science, technology, engineering, and mathematics (STEM) education (Anderson, 2011; Freeman et al., 2014; Vilardi, 2013). Studies have shown that teachers have a positive opinion of the role of IBL but struggle to find ways to implement it into their daily lesson plans (Dorier & Garcia, 2013; Englen et al., 2013; Fitzgerald et al., 2017; Vhurumuku, 2015; Wallace & Kang, 2004). The goal of this study is to examine the perceptions of secondary science teachers to determine their intended use of IBL, their actual use of IBL, and what barriers they perceive are limiting factors between intent and implementation. This chapter will describe the research problem in the study, the significance of the study, the research purpose and questions, and provide definitions to key terms.

Research Problem

The goal of secondary education is to prepare students to succeed in post-graduation careers or college courses (Educate Texas, 2020). Students entering college to pursue STEM careers along with high school graduates entering into the STEM workforce are unprepared for the rigor of post-secondary life (Freeman et. al., 2014; Jansen et al., 2013; Mah, 2016; OECD, 2018; Woolley et al., 2018; Zeineddin & Abd-El-Khalick, 2010). This lack of preparation of STEM students has led to a large number of undergraduates failing introductory college course work, and ultimately less than 40% complete their initial STEM degree (Freeman et al, 2014 & PCAST, 2012). Reform efforts in education continue to put emphasis on science education as essential for the growth of the nation (National Academy of Science, 2007; Committee on STEM Education, 2018). This educational reform is considered the most critical area of need in the United States (U.S.) if it is to remain competitive in an ever increasingly technical world market (OECD, 2018).

In 2013, the Next Generation Science Standards (NGSS) were released setting new standards for the teaching of science in secondary schools (NGSS, 2020). One of the key components of this reform was the proposed shift in teaching methodology calling for a reduction of teacher-centered instruction through increased use of student-centered practices, like IBL. Inquiry-based learning is defined as student-centered learning involving many of the same processes as the scientific method, in which students form hypothesis and research their own answers to guided questions (Bell, 2010). However, the most commonly used teaching method in secondary science pedagogy continues to be direct instruction, a strategy that emphasizes the memorization of terminology through note taking and repetition through assigned worksheets (Freeman et al., 2014). This strategy works to ensure students are prepared for exams where recall or vocabulary is the basis of most testing questions, however, it does very little in preparing students to conduct research, problem solve, or utilize individual critical thinking skills.

Unfortunately, state standards that are increasingly tied to high-stakes testing continue to steer teachers towards vocabulary-based instruction that promotes test taking and not essential knowledge or skills (Anderson, 2011; Au, 2007). In a study by Moon et al. (2003), teachers reported spending substantial time prepping for and teaching to the state exams. This study also indicated that teachers felt the best practice to prepare students for these exams was to simulate the exams in the learning environment. When students are exposed to IBL it is often in the form of structured inquiry where the teacher asks a question, and the answer is predetermined based on provided steps that students follow like a recipe (Colburn, 2000). These activities, like any inquiry activity, can be designed to allow students more freedom to make choices in the steps to take to answer the question (Correia & Harrison, 2020). These next steps include guided inquiry, where the teacher asks the question but provides options for students to answer using their own methods and open inquiry in which the students form their own questions about a subject and develop their own unique problem-solving process (Colburn, 2000; Walker, 2015).

Another factor affecting the use of IBL is that teachers often use instructional methodologies that are familiar and based on their beliefs about what is best for their students (Correia & Harrison, 2020; Nespor, 1987). Teacher opinion or perception impacts how teachers structure learning in the classroom. The unwillingness of teachers to alter their methodology occurs regardless of whether teacher's opinions are based on prior experience, perceptions of student abilities, or barriers to learning (Haberman, 1991; Tofel-Grehl & Callahan, 2017; Wallace & Kang, 2004).

With so much emphasis on the future of our students, gaining a better understanding of teacher beliefs and practice of IBL in secondary science classrooms may help improve science education and meet the goals laid out in national education reform efforts (Capps et al., 2016; Fitzgerald et al., 2017). These reform efforts focus on providing students with the essential skills to succeed outside the structured environment of the secondary science classroom (National Academy of Science, 2007; Committee on STEM Education, 2018; NGSS, 2020). In place of traditional teacher-based instruction and "drill-and-kill" style lessons, a transition to IBL can improve student learning and understanding at all levels of education (Anderson, 2011; Freeman et al., 2014; Vilardi, 2013). While these studies show a link between inquiry and student success, there is still debate regarding teacher perceptions to, their current use of, and the perceived problems for increased use of inquiry-based instruction.

Significance of the Study

To best serve the future of STEM students, classroom reform, specifically the increased use of IBL in secondary science instruction, is essential. By increasing student knowledge students will be better prepared to fill the needs of the STEM career fields and compete in a global economy that is increasingly tied to STEM (Bicer et al, 2015; Filipi & Agarwa, 2017; Freeman et al., 2014). This particularly applies to students taking courses tied to high-stakes testing, where best practice is often overlooked as teachers feel forced to teach to the test (Anderson, 2011; Au, 2011; Pedulla et al., 2003). In gaining a better understanding of how teachers perceive IBL, curriculum specialists can begin to develop and implement plans encouraging the use of IBL in the science classroom thus improving student content knowledge, critical thinking skills, and problem-solving abilities.

Research Purpose and Questions

The purpose of this study was to examine teachers' perceptions on the intent to use, the use of, and the barriers to implementing inquiry-based learning. The following questions guided this study:

1. To what extent do science teachers intend to use IBL activities in their daily lesson plans?
2. To what extent do science teachers use IBL in their daily lesson plans?
3. To what extent do science teachers perceive barriers as limiting their use of IBL in their daily lesson plans?
4. Is there a relationship between science teachers' intent to use IBL and the use of IBL in daily lesson plans?
5. How well do science teachers understand the concept of IBL?
6. How do science teacher perceptions impact their daily use of IBL?

Definitions of Key Terms

The following is a list of key definitions used in this dissertation.

Barriers - Any teacher perceived problem to increased implementation of inquiry-based instruction (Englen et. al., 2013).

Guided Inquiry – Guided inquiry occurs in a lesson when the teacher provides the problem and materials while the students develop their own process to solve the problem (Colburn, 2000)

High-Stakes Testing - Tests that are linked to possible sanctions for failure to meet certain passing standards (Anderson, 2011).

Inquiry-based learning (IBL) - A teaching methodology that allows students to discover for themselves the material being presented. In inquiry the teacher is a facilitator of the lesson not a director of student activity (Bell, 2010).

Open Inquiry – A type of learning where students formulate their own question, use available materials, and develop their own answer to the problem independent of teacher instructions (Colburn, 2000).

Perceptions - Teacher attitudes, opinions, and understanding of inquiry-based instruction (Englen et al., 2013).

Structured Inquiry – During structured inquiry, the teacher provides students with a hands-on problem to investigate along with the materials and procedures to follow, the outcome is unknown to students but known to the teacher (Colburn, 2000).

Conclusion

This chapter laid a framework for the need to examine the relationship between teacher perceptions and barriers to the implementation of inquiry-based learning in secondary science classrooms. With the need to remain competitive in a global economy, the significance of American students' success in STEM is more important than ever

(Bicer et al., 2015; Filipi & Agarwa, 2017; Freeman et al., 2014). Chapter two will provide a discussion of the literature relevant to the topic including the need for improvement in science education, the process of inquiry-based learning, the importance of teacher beliefs on teaching practice, and potential barriers to the implementation of inquiry-based learning.

CHAPTER II:

LITERATURE REVIEW

The projected need for skilled STEM employees is far greater than what our current education system can provide (OECD, 2018; PISA, 2015). This gap in STEM education outlines the need for improvements in both teaching of the STEM content and student practical learning in STEM fields. Science education has continued to be the focus of reform efforts via changes in theoretical frameworks, teaching practice, and local and federal policy (Anderson, 2011; Freeman et al, 2007; Walker, 2015). The general consensus of these reform efforts has been to call for a shift from teacher-centered learning to more student-focused, inquiry-based learning (IBL) (Anderson, 2011; Capps & Crawford, 2012; Chen et al., 2020; Freeman et al., 2007; Fitzgerald et al., 2017). However, these reform efforts have seldom been met with any major changes in the teaching of science in the classroom (Englen et al., 2013; Capps & Crawford, 2012; Dorier & Garcia, 2013).

In its current state the education system teaches concepts and definitions without emphasizing real world application (Capps & Crawford, 2012; Marshall & Drummond, 2006; Marshall, 2010; Robertson & Elliot, 2018). As Marshall (2010) points out, school science has become a “spectator sport” that prevents deep understanding and creative learning. Taylor et al. (2008) found that practicing scientists also worried about “poor teacher preparation, the need for students to have more opportunities to develop critical thinking skills, more hands-on activities with science, breadth versus depth of content knowledge, and an interest in seeing students apply science to real-world contexts” (p. 1064). Even when teachers understand or believe that other methodologies are better for students’ long-term success, personal and professional barriers prevent these teachers from enacting best practices in the classroom (Anderson, 2011; Au, 2007; Harrison, 2015; Marshall & Drummond, 2006; Robertson & Elliott, 2018; Wallace & Kang, 2004; Zohar & Agmon, 2018). Another factor that affects how teachers approach student learning is their inherent beliefs about the role of teachers, the ability of students, and the effects of outside pressure on their practice (Correia & Harrison, 2020; Harwood et al., 2006; Nespor, 1987; Tofel-Grehl & Callahan, 2017; Wallace & Kang, 2004). This study will focus on the differences among teacher beliefs about the practice of IBL, the application of IBL in daily lessons, and perceived barriers to further implementation of IBL. Therefore, this chapter will examine some of the existing research with regards to the problems in STEM education, the process of IBL, current teaching practices in science classrooms, the influence of teachers' beliefs and how they teach, and the existing barriers to implementation of IBL.

A Historical Perspective on Inquiry-Based Learning

According to Castro and Morales (2017), inquiry-based learning is a process where "students explore authentic problems using tools and skills of the discipline and which requires more active student participation and higher order thinking skills" (p. 49). The use of IBL in science teaching was championed early on by John Dewey (1910) who believed that there was too much fact-based teaching and not enough practical learning in the science classroom. In Dewey's own words regarding the teaching of science; "science teaching has suffered because science has been so frequently presented just as so much ready-made knowledge, so much subject-matter of fact and law, rather than as the effective method of inquiry into any subject matter (Dewey, 1910, p.124)." And, in the prolog to the work by Harms and Yager (1891), Robert Yeager expressed the benefit of IBL saying, "if science is presented in a way it is known to scientists, it will be inherently interesting to all students (p. 9)."

Since Dewey's recommendation that science teaching be founded in IBL, the idea of inquiry has been highly embraced (Colburn, 2000). With this acceptance has come revisions to state and national teaching standards along with government led reform efforts have repeatedly called for the increased usage of IBL in secondary science (Committee on STEM Education, 2018; National Research Council, 2012; NGSS, 2013; TEA, 2020). However, the acceptance of IBL as a superior method of science instruction has not translated into widespread usage across secondary science classrooms (Anderson, 2011; Au, 2007; Englen et al., 2013; Roehrig & Luft, 2004; Schoenfeld & Kilpatrick, 2013; Tofel-Grehl & Callahan, 2017; Wallace & Kang, 2004). And so, the question that remains is: with the amount of reform efforts and reported widespread embracing of IBL as a method of instruction, why do teachers continue to use fact-based presentations of knowledge without practical components in the teaching of science? The following review of the literature addresses what is currently known, and the study conducted herein, seeks to find more in-depth answers to this question.

Problems in STEM Education

In Rising Above the Gathering Storm, congressional committee members emphasized growing concerns that the U.S. was falling behind the rest of the world in areas of science and technology; and that this was a direct result of problems with science education (Committee on Science, Engineering and Public Policy, 2007). Between 2009-2015 the growth of employment in STEM occupations was double that of non-STEM employment add to this that 99 percent of STEM employment requires some type of postsecondary education (US Bureau of Labor and Statistics, 2015) and we see that fixing the problems in science education is of great importance.

If students are graduating high school without the essential skills to succeed in STEM, they will have difficulty applying what they have learned in less structured environments like higher education. This lack of scientific reasoning skills in students has led to a large number of STEM undergraduates failing introductory college course work, with less than 40% completing their initial STEM degrees (Freeman et al, 2014 and PCAST, 2012). The impact of the deficiencies in STEM skills extends beyond just the economic impacts on a nation; it negatively impacts all aspects of society, possible causing poorer health and social unrest (OECD, 2018). To decrease the knowledge gap and prepare students to enter the post-secondary market there must be an emphasis on improving the skills of graduating students (OECD, 2018).

Many science education reform programs have intended to do just that. A new Framework for Teaching of K-12 Science emphasized scientific and engineering practice, cross-curricular learning and the streamlining of the curriculum to prioritize revision of key concepts over the course of multiple years (National Research Council, 2012). In developing the Next Generation Science Standards (NGSS), scientific and educational research committees paired together to define a new standard for science teaching, including calls for improvements in the methods in which science is taught (NGSS, 2020). The White House's STEM Education Strategic Plan calls for the teaching of STEM through real world applications including formal and informal learning in schools (Committee on STEM Education, 2018). The amount of reform initiatives and the commonality among these documents implies that the major problems in the teaching of STEM lie in the practice of teaching itself. There appears to be a division in the traditional method of fact-based teaching and the implementation of the skills-based instruction called for in these reform documents.

Traditional Teaching Methodologies in Science

In the 1960s growing concern over the lack of scientifically literate graduates resulted in the idea that the main role of teaching science was to teach scientific facts, laws, and theories (Walker, 2015). As a result, the “traditional” way of direct instruction in science lessons became focused on “exposition, memorization, and cookbook laboratory work” (Cobern et al., 2010, p. 83). In this teacher centric classroom, the teacher dominates the discussions and the student acts only to participate through guessing the answer to questions the teachers hold in their head. Many of the problems that STEM students face are a result of this traditional methodology of teacher focused instruction (Anderson, 2011; Bicer et al., 2015; Bicer et al., 2017; Collier et al., 2018; Filippi & Agarwal, 2017).

A central point in this problem is that teachers do not plan learning experiences where the goal is to influence student’s ideas about science (Harrison, 2015; Roehrig & Luft, 2004). Instead, these reports claim, teachers plan how to introduce students to the content of science, either factual or conceptual in nature, but in either case the teacher is responsible for the construction of knowledge and the student is a passive recipient. Marshall (2010) takes this even further, lamenting the current state of science instruction in the following way:

> Most school science is experienced as a passive acquisition of large amounts of often unconnected, sterile, and topical content; devoid of emotion, joy, and wonder; irrelevant and detached from the human experience. In addition, students are disengaged and compliant recipients; information is inert and not connected to real world-students’ needs, interests, curiosities, or questions; content is decontextualized and prescribed so there is little time for exploratory forays or following intriguing questions because the focus is on excessive coverage; and the science disciplines are taught within very tight boundaries. (p 51)

This type of learning environment is not conducive to improving student knowledge, or in fostering the attitudes of discovery that are imperative in grooming future scientists. In contrast to direct instructional techniques, inquiry-based learning has been shown to improve students' performance on standards-based tests and in developing practical skills for scientific research (Freeman et al., 2014; Walker, 2015).

Inquiry-Based Learning

The idea of inquiry-based learning (IBL) is not a new concept. In 1996, the National Science Education Standards called for the use of inquiry activities in the classroom that mirrored scientific inquiry in practice (NRC, 2012). On the official website of the Next Generation Science Standards (2020), is the following statement:

> Science and Engineering Practices describe what scientists do to investigate the natural world and what engineers do to design and build systems. The practices better explain and extend what is meant by "inquiry" in science and the range of cognitive, social, and physical practices that it requires. Students engage in practices to build, deepen, and apply their knowledge of core ideas and crosscutting concepts. (ngss.org)

According to the standards in the Texas Essential Knowledge and Skills (TEKS) for 6th grade science, the first line under scientific investigation and reasoning states:

> To develop a rich knowledge of science and the natural world, students must become familiar with different modes of scientific inquiry, rules of evidence, ways of formulating questions, ways of proposing explanations, and the diverse ways scientists study the natural world and propose explanations based on evidence derived from their work. (TEA, 2020 Section 112.18. Science, Grade 6)

These accountability-based standards continually call for more student-centered IBL to take place in the classroom.

Inquiry-based learning isn't the only method for teaching of science in the classroom, but it is important because it exposes students to the type of methods utilized by practicing scientists, helping students to develop a deeper understanding of science and more importantly leads to the development of critical thinking skills (Capps & Crawford, 2012; Colburn, 2000; Walker, 2015). According to Walker (2015), just conducting a classroom experiment alone does not constitute IBL. These typical classroom experiments are described as involving a teachers' topic explanation and providing students with an activity to complete along with an exact list of all methods the students are to follow. The results of this activity are known by the teacher and will be the same for all participants as long as they follow the instructions provided.

The process of IBL differs greatly from traditional structured experimental designs seen in many science classrooms (Walker, 2015). Inquiry-Based Learning supports the scientific method of discovery because students ask a question, plan and design experiments, collect data and utilize this data to develop a unique answer to their problem (Bell, 2010; Capps & Crawford, 2012; Feyzioglu, 2019; Walker, 2015). Through this, students grow and develop their own understanding of science in a manner that is best suited to their individual learning styles while developing the essential skills to be successful post high school graduation (Englen et al., 2013). Inquiry has also been shown to be effective in increasing student achievement in science (Bicer et al., 2015; Filippi & Agarwal, 2017; Freeman et al., 2007; Freeman et al., 2014).

While the process of IBL is founded on many of the same principals as authentic scientific inquiry as conducted in a laboratory; IBL in the classroom is simpler allowing the student to uncover observable regularities (Colurn, 2000; Dudu & Vhurumuku, 2012).

While this may not be true scientific inquiry, many of the steps are the same. Students ask questions and form hypotheses, just like in scientific experiments. Students also conduct research, although in this case the research is more limited due to the lack of complex equipment and background knowledge of the scientific process and materials (Dudu & Vhurumuku, 2012; Walker, 2015).

Within the process of IBL there are differing levels of “openness” that students can experience, it is therefore important to establish a classification system for IBL (Colburn, 2000; Marshall, 2015). The levels of inquiry can be described based on who provides the question upon which the lesson is based (Colburn, 2000; Waker, 2015; Tafoya et al., 1980). Using this method to describe inquiry provides four levels of openness: (1) confirmational exercises, (2) structured, (3) guided, and (4) open inquiry-based learning. Confirmational exercises possess none of the traits of inquiry; these lessons have a known and repeatable outcome known by the teacher before the students are given the lesson. Structured inquiry occurs when the teacher provides the students with both the question and the methods, but the answer is unknown to the students. In guided inquiry the teacher provides only the question; it is up to the student to determine the methods and learn the answer. Open inquiry is true inquiry; the student is provided with an idea then formulates the question, methods, and finds his or her own unique answer to the problem.

Within any lesson lies the ability to implement some form of inquiry (Walker, 2015). At the most basic level the idea that students can find the answer to questions without being instructed on how or where to look for the answers develops some small amount of problem-solving ability and can be linked back to guided inquiry. Englen et al. (2013) found that guided inquiry was the most common form of instruction being carried out by teachers they observed, although this only occurred as parts of some lessons. In general, they found that the parts of inquiry-based learning that were present were those that gave teachers some degree of control in the lesson. Regardless of teacher perception and educational reform efforts, there are many barriers that prevent the widespread adoption of IBL.

Barriers to Inquiry-Based Learning

Revisions in state and national teaching standards along with government led reform efforts have repeatedly called for the increased usage of IBL in secondary science education (Committee on Conceptual Frameworks, 2012; Committee on STEM Education, 2018; NRC, 2012; NGSS, 2013; TEA, 2020). Studies have also shown that teachers, overall, have a positive opinion of science standards and the use of inquiry in the classroom (Anderson, 2011; Englen et al. 2013, Wallace & Kang, 2004). With the combination of government reform initiatives, revisions in state and national science standards, and positive teacher perception to IBL the question remains as to why traditional teaching methodologies remain the standard in science classrooms. The implementation of IBL is influenced by a multitude of different factors (Roehrig & Luft, 2004). The most important factors that seem to limit the widespread implementation of IBL are a multitude of teachers' perceived barriers (Anderson, 2011; Au, 2007; Englen et al., 2013; Roehrig & Luft, 2004; Schoenfeld & Kilpatrick, 2013; Tofel-Grehl & Callahan, 2017; Wallace & Kang, 2004).

According to Nespor (1987), what teachers practice in the classroom is a direct result of their ways of thinking and understanding. He claimed that these beliefs are made up of episodic knowledge that is characterized by remembered stories and events. In other words, teachers' practices in the classroom are grounded in their beliefs about the role of a teacher as an educator and are founded on how teachers perceived their own education. Teacher beliefs that are centered around student autonomy would be more likely to implement IBL; while teachers whose beliefs are centered in their personal responsibility for student learning would focus on more teacher centered practices (Marshall & Drummond, 2006). It has also been shown that teachers beliefs are often in conflict between their perceptions of what is best for their students and what society claims is best for the student (Anderson, 2011; Wallace & Kang, 2004). “If we are interested in why teachers organize and run classrooms the way they do we must pay attention to the goals they pursue which may be multiple, conflicting, and not at all related to optimizing student learning” (Nespor, 1987, p. 325).

Teacher beliefs are not isolated to the methodology itself. A study by Tofel-Grehl and Callahan (2017), demonstrated the effect of teacher opinion on learning outcomes; suggesting that teachers who saw their students as high achievers, or gifted, included greater opportunities for inquiry in their lessons and higher rigor in the classrooms than teachers who did not feel that their students could meet those challenges. However, research has shown that both gifted and non-gifted students are equal in their ability to engage in IBL (Chen et al., 2020). This is mirrored in the perceptions of beginning teachers who reported low student motivation and ability as the greatest constraint against inquiry (Roehig & Luft, 2004). Immaturity and laziness in students and its effect on teacher perceptions and use of IBL is also observed in experienced secondary science teachers (Wallace & Kang, 2004). Teacher beliefs may reflect positively on the implementation of IBL but may be hindered by the scope and sequences of the curriculum adopted by the state or the district.

In most countries, central and state authorities establish lists of standards for teaching science that define both instruction time and the scope of sequence of the curriculum (OECD 2018). Both the NGSS and Texas Essential Knowledge and Skills (TEKS) contain a list of standards for the teaching of science in the classroom. With the implementation of GOALS 2000 (Goals, 2008), the Elementary and Secondary Education Act (1994), and No Child Left Behind Act (US Dept, of Ed, 2004), the standardized testing that had become routine also became “high-stakes”, meaning that there were possible sanctions that could be placed on schools who failed to meet state benchmarks (Anderson, 2011; Au, 2007). Standardized testing is considered one of the biggest hurdles to the widespread implementation of IBL and similar student-centered learning styles (Anderson, 2011; Au, 2007; Scogin et al., 2017). The pressures teachers feel from having to prepare students to pass standardized exams and teach a large amount of material in a relatively short amount of time promote the use of lessons built on the old style of teacher led instruction, with lectures and note taking as the introduction to a topic, followed by worksheets and reinforcement activities to drive home the lesson (Freeman et al., 2014).

Both teachers and scientists agree, when questioned, that too much time is spent on preparation for exams and not enough on the nature of scientific learning (Taylor et al., 2008). Teachers often reject activities that appear fun or interesting, or activities that would adequately challenge high achievers in favor of material that prepares students to pass state exams (Anderson, 2011; Moon et al., 2003). In 1965 the United States implemented testing to determine the effectiveness of teaching occurring at public schools and, in 1994 standards and test-based accountability became common (Anderson, 2011). These standards-based exams were designed to ensure that teachers and students worked to meet tougher academic challenges based on state standards (Pedulla et al., 2003) and many states, such as Texas, have made these types of tests “high-stakes” with the threat of possible sanctions, like decreased funding and closure, based on student achievement on tests (TEA, 2020). As a result, teachers worry about the number of students that will pass a test each year. They, therefore, spend a large amount of time and resources focused on their belief that passing the test is crucial for their students. The rigors of these state exams have placed considerable pressure on school districts and teachers, causing them to abandon best-teaching practices in favor of lecturing and other teacher driven methodologies (Anderson, 2011; Au, 2007; Moon et al., 2003). Anderson (2011) found that teachers and administrators felt that accountability-based standards drove the teaching of science toward the memorization of facts at the detriment of student learning. Au (2007, p. 262) also reported that teachers were increasingly fragmenting the teaching of knowledge into “individual and isolated test-sized pieces”. While teachers continue to teach-to-the-test studies show that there is no significant difference in students test taking abilities between traditional science instruction and IBL (Freeman et al., 2014; Scogin et al., 2017). The amount of material that teachers are expected to cover based on adopted curriculum standard leads many teachers to feel pressed for time in completing the materials.

Another factor that affects the curriculum at traditional schools is time (Dorier & Garcia, 2013; Englen et al., 2013; Fitzgerald et al., 2017). Curriculum standards often emphasize the breadth of the content over the depth of scientific theories (Donnelly & Sadler, 2008; Taylor et al., 2008). This translates into a curriculum that covers a wide range of scientific topics at an introductory level. For example, the TEKS for high school biology consist of 13 topics divided into 44 subsections, while the NGSS for high school life science, which can incorporate multiple subject areas, are divided into 4 topics with 22 subsections (NGSS, 2020; TEA, 2020). As a result of the amount of curriculum that teachers are faced with direct instruction becomes favored over the processes of IBL solely on the basis of the time required to cover so much material (Au, 2007; Englen et al., 2013; Dorier & Garcia, 2013; Fitzgerald et al., 2017). “The importance of systemic restrictions highlights that any effort to change teaching practice has to take organizational support and change into account" (Englen et al., 2013 p. 833). However, within all standardized curricula there is some leeway for teachers to impart their own teaching ideals into the classroom (Dorier & Garcia, 2013). The process of IBL itself is also time consuming.

Teacher familiarity with inquiry is another issue impeding its implementation in the classroom (Anderson, 2011; Capps & Crawford, 2012; Oner & Capraro, 2016). Teachers are often mistaken in what IBL involves in the classroom. Capps and Crawford (2012) found that teachers often claimed to use IBL but when under observation little if any inquiry was being conducted in the classroom. Teachers often struggle to define true IBL and often confuse it with other hands-on approaches or active learning styles (Fitzgerald et al., 2017). This is a common misconception, since not all hands-on activities are inquiry-based (Dudu & Vhurumuku, 2012). If teachers are unaware of the process of, or mistaken in what types of activities constitute IBL, then we cannot expect them to easily depart from the old methods of drill and kill. While teachers understand the need for reform and may even have the desire to implement more inquiry, they have little knowledge of how to put their ideas into practice (Englen et al., 2013; Dudu & Vhurumuku, 2012; Oner & Capraro, 2016).

Theoretical Framework

The framework of this study is grounded on the constructs of instructional strategy and teacher perceptions. The inquiry-model of learning can be viewed as pedagogy or the method in which science is taught (Capps & Crawford, 2012). The process of IBL is based on students as the builders of their own foundation of knowledge. Cobern et al. (2010) found that:

> "Many educators feel that inquiry instruction rather than direct is most in keeping with the widely accepted constructivist theory of how people

> learn, i.e., that meaningful knowledge cannot simply be transmitted and absorbed but learners have to construct their own understanding" (p.82).

According to Lindsey (2017) the constructivist paradigm is based on the idea that the student constructs his or her own information. Constructivists believe that the learning process is an active one where knowledge is constructed, not acquired. Within the paradigm of constructivism is Bruner's theory of discovery learning (learning-theories.com, 2021). Inquiry-based learning takes place in situations that involve problem solving and allows for the learner to draw on his or her own experiences to solve problems (Bell, 2010). There are many types of constructivism some good and some bad, with the good emphasized in calls for active participation by the learner and the social nature of learning (Phillips, 1995). It is within the realm of the "good" that inquiry takes place. Walker (2015) describes constructivist theory of learning by four key features:

- Prior knowledge: what the learner possesses before being introduced to new ideas. This allows the learner to construct new ideas and build upon their knowledge base and help to eliminate any misconceptions they have.
- Knowledge is constructed: learners create their own ideas. Knowledge is not passed from teacher to student. And the knowledge that students gain fits within the context of their prior knowledge.
- Learning is active: active learning takes place when students work to build upon their own knowledge base. This occurs when learners are actively engaged in the process of discovery.
- Learning depends on the environment the learner is in: the social and physical environment greatly affects the way in which a learner gains knowledge. Knowledge is best gained when the learning environment

> encourages students to see relevance in their actions and acquisition of knowledge. (p. 33)

When teaching under the ideals of constructivism, the teacher takes the role of a mentor, guiding students in the process of learning. This is different from the traditional approach where the teacher acts to give their knowledge to the students. One of the major factors preventing the use of IBL in the classroom is teacher beliefs about teaching and learning (Englen et al., 2013). How teachers approach learning is based on their underlying beliefs of their teacher roles (Nespor, 1987; Roehrig & Luft, 2004; Wallace & Kang, 2004). Many teachers' belief structures are founded in the behaviorist view of learning (Magliaro et al., 2005; Walker, 2015). This belief system is the foundation of direct instruction and the drill-and-kill type lessons that dominate the science classrooms of many institutions.

Conclusion

The literature reviewed above provides a framework for the ideas involved in this study regarding the connection between the problems in science education, traditional teaching methodologies and the implementation of IBL. Within the above literature there exists a gap in knowledge comparing the use of IBL between 6-8th grade teachers and 9-12th grade teachers. The following chapter will describe the methodology to be used by the researcher during the current study. This chapter will include an overview of the research problem, research purpose and questions, research design, population and sample, instrumentation, data collection procedures, data analysis, privacy and ethics considerations, and limitations for this study.

CHAPTER III:

METHODOLOGY

The purpose of this study was to examine teachers' perceptions on the intent to use, the use of, and the barriers to implementing IBL. A purposeful sample of 6th – 12th grade science teachers from Region 4 in southeast Texas were solicited to participate in this study. The participants were administered a modified version of the Promoting Inquiry in Math and Science (PRIMAS) Survey to assess their perceptions of, use of, and barriers to implementing IBL and six participants were invited to participate in semi-structured interviews. Quantitative data were analyzed using descriptive statistics, while responses from the interviews were analyzed using an inductive thematic coding process. This chapter presents an overview of the research problem, operational definitions of the theoretical constructs, the purpose of the research and the corresponding research questions, the research design, the population and sampling of the participants, instrumentation, how the data was collected and analyzed, along with ethical considerations, and the limitations of the study.

Research Problem

There is a need to increase student preparedness for the rigors of college and careers in STEM (Freeman et. al., 2014; Jansen et al., 2013; Mah, 2016; OECD, 2018; Woolley et al., 2018; Zeineddin & Abd-El-Khalick, 2010). Current teaching models fall short when it comes to this style of preparation (Freeman et al., 2014). All too often, teachers spend the majority of instructional time using outdated techniques to prepare students for an exam that claims to test concept knowledge, but in reality, focuses on student memorization of terminology within a well-defined set of standards. In order to succeed after high school, students need critical thinking skills. These skills are best taught through inquiry. Inquiry-based learning is student centered and allows for personal discovery and growth. It teaches students to ask questions, then seek the answers. This mimics real life where the answer to a problem might not be a Google search away. This study will examine 6th – 12th grade science teachers based on the extent to which they intend to implement IBL, the extent to which IBL is used in the participants daily lesson activities, along with the extent to which participants' perceived barriers to IBL limit its daily use.

Operationalization of Theoretical Constructs

This study consists of three constructs: (a) intent to use, (b) use of, and (c) barriers to IBL. The intent to use inquiry is defined as a combination of teacher orientation towards IBL (Englen et al., 2013) and desire to use IBL in daily lesson plans as measured by teacher responses to the survey questions. Teacher's use IBL is defined as their reporting of the frequency of interactive teaching, the use of hands-on learning, and of student investigation and focus on application (Capps et al., 2016; Englen et al., 2013; OECD, 2009). Barriers to IBL are defined as teacher perceptions to internal and external pressures that prevent intended improvements to spread naturally through the daily activities of science teachers where large-scale implementation relies on perceptions to success (Hall & Hord, 2001). For the purpose of this study, the above constructs were measured using a modified version of the PRIMAS.

Research Purpose and Questions

The purpose of this study was to examine teacher's perceptions on the intent to use, the use of, and the barriers to implementing IBL. The following questions guided this study:

1. To what extent do science teachers intend to use IBL activities in their daily lesson plans?
2. To what extent do science teachers use IBL in their daily lesson plans?

3. To what extent do science teachers perceive barriers as limiting their use of IBL in their daily lesson plans?
4. Is there a relationship between science teachers' intent to use IBL and the use of IBL in daily lesson plans?
5. How well do science teachers understand the concept of IBL?
6. How do science teacher perceptions impact their daily use of IBL?

Research Design

This research study utilized a mixed method (Quan→qual) design regarding the perceptions of IBL in grades 6-12 science classrooms. The design consisted of a quantitative and a qualitative phase. The advantage of implementing this design is that it allowed for a more thorough and in-depth exploration of the quantitative results by following up with a qualitative phase. A purposeful sample of 6-12th grade science teachers, teaching within Region 4 in southeast Texas was solicited to complete the Promoting Inquiry in Math and Science (PRIMAS) Survey and participate in semi-structured interviews. For the quantitative phase, survey data were analyzed using frequencies and percentages, Qualitative data, based on responses from the interviews, were analyzed using an inductive thematic coding process.

Population and Sample

The population of the study consisted of 6-12th grade science teachers from Region 4 in southeast Texas. This region serves approximately 1.2 million students enrolled across 48 districts and 39 charter organizations. Of the Region 4's student population, 0.4% were American Indian or Alaskan Native, 7.0% were Asian, 18.5% Black or African American, 51.5% Hispanic/Latino, 20.4% White, 0.1% Native Hawaiian/Other Pacific and 2.1% Two of More Races. Of the total, 24% were English Language Learners (ELL) and 61.7% were at-risk. Table 3.1 displays the student demographics of Region 4 and shows the race/ethnicity and socioeconomic status of students for the 2019-2020 school year (TEA, 2020).

Table 3.1

Region 4 Student Demographics

	Frequency (n)	Percentage (%)
1. Total Students	1,248,425	
2. Race/Ethnicity		
American Indian or Alaska Native	5,159	0.4
Asian	88,105	7.0
Black or African American	228,979	18.5
Hispanic/Latino	646,031	51.5
Native Hawaiian/ Pacific Islander	1.530	0.1
White	251,822	20.4
Two or More Races	26.700	2.1
3. Special Population		
Economically Disadvantaged	770,858	61.7
English Language Learners	299, 668	24.0

Region 4 had 644,577 students enrolled in grades 6-12 for the 2019-2020 school year. This ESC employed 77,551 teachers to educate its students. Table 3.2 shows the demographics for the teachers within Region 4. Of these teachers, 77.5% were female and 22.5% were male. Of this population 21.2% were African American, 21.1% were Hispanic, 52.5% were White, 0.3% were American Indian, 3.4% were Asian, 0.3% were Pacific Islander, were 1.3% were Two or More Races. A purposeful sample of 6-12th grade science teachers throughout Region 4 in southeast Texas were solicited to participate in this study.

Table 3.2

Region 4 Teacher Demographics

	Frequency (n)	Percentage (%)
1. Total Teachers	77,551	
2. Race/Ethnicity		
American Indian or Alaska Native	245	0.3
Asian	2,518	3.4
Black or African American	15,853	21.2
Hispanic/Latino	15,753	21.1
Native Hawaiian/ Pacific Islander	203	0.3
White	39,178	52.4
Two or More Races	1,006	1.3
3. Gender		
Female	57,770	77.5
Male	16,986	22.5

Participant Selection

Teachers, teaching 6-12th grade science within Region 4 in southeast Texas were sent a cover letter soliciting their participation in the study along with an anonymous link to the PRIMAS survey. The PRIMAS survey was used to collect teacher perception data from a purposeful sample of teachers. From the teachers completing the PRIMAS survey, six were also invited to participate in an 20-30-minute semi-structured interview in an attempt to better understand their knowledge, usage, and any potential barriers they perceived to inquiry-based instruction. Based on their responses to their daily use of IBL on the PRIMAS survey two groups of teachers were selected, on High-USE and one Low-Use group. This division of participants ensured that the perceptions of teachers at both levels of IBL usage were represented in the study.

Instrumentation

The survey adopted for this study is the Promoting Inquiry in Math and Science Survey (PRIMAS) that was previously developed for a large-scale study on inquiry-based learning and teaching across 12 European partner countries (Englen & Maas, 2011). The instrument was originally piloted by a group of five science teachers, their responses were not included in the final report. The teachers in the pilot study were asked to identify and comment on items that they regarded as being unclear. No readability issues were raised during the piloting process and the questionnaire was adopted in its original form. This survey was designed with three things in mind: (a) the assessment of teacher opinions to inquiry-based instruction; (b) to inquire into potential problems regarding the future implementation of inquiry-based learning; and (c) determine the current level of inquiry-based instruction in practice by participants.

The survey's original design of 14 questions has been shortened to nine questions (three items regarding demographics, four items pertaining to teacher perceptions of inquiry, and two items regarding teachers' current practice). Each question is broken into between 5-12 sub-questions. The questions are scored on a 4-point Likert-Scale (1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Somewhat Agree, 4 = Strongly Agree). For the purpose of this study, the original subscales were reclassified to include only the questions that pertained to each of the study's research questions. These subscales are Intent to Use (composite 7-28), Use of IBL (composite 19-76), and Barriers to Use (composite 15-60). The greater the composite, the more intent, use, or barrier. The Cronbach's alpha for the modified PRIMAS survey subscales identified as: "Intent to Use" 0.840, "Use of IBL" 0.909, and "Barriers to Implementation" 0.846.

Data Collection Procedures

Quantitative

The researcher successfully obtained permission to conduct the study from the University of Houston-Clear Lake (UHCL) Committee for the Protection of Human Subjects (CPHS) before collecting data. Following approval from the UHCL-CPHS, the PRIMAS survey was distributed via e-mail to individual 6-12 science teachers working within the ESC in southeast Texas. Teachers accessed the survey via an anonymous link provided in the email. Prior to answering the questions teachers were provided a survey cover letter detailing the purpose of the research study, requesting their involvement in the study, and establishing consent to participate in the study through opening the link to the survey. The survey was designed using Qualtrics and distributed through teacher e-mail accounts sent out bi-weekly for a period of 8-weeks.

Qualitative

The teachers who participated in the survey were asked to provide a personal definition for IBL and to provide voluntary contact information in order to participate in one-on-one interviews. A purposeful sample of three high-IBL use teacher and three low-IBL use teachers were selected for the interview process based on their self-reporting of IBL usage during the survey. During the interview participants were asked to provide information regarding their understanding of IBL. This included being asked to provide descriptions of their current teaching practice, including examples of inquiry-based lessons they may have conducted in the past. Additional information regarding teacher perceptions to IBL and perceived barriers to IBL was also collected. All interviews were conducted using ZOOM. Participant responses were video recorded and transcribed by the researcher. The data collected was stored in two locations: the ZOOM cloud server, and the researcher's personal computer hard drive. Both the ZOOM server and hard drive are secure, and password protected. The computer is being kept within a locked office for the duration of the study. At the conclusion of the study, the data will be removed from the researcher's computer, placed onto a secure flash drive and will be stored in a safe for five years, after which time the data will be destroyed.

Data Analysis

Quantitative:

Following data collection, the data were downloaded from Microsoft Excel into an IBM SPSS statistics spreadsheet for further analysis. In order to answer the research questions one through three (teachers' intent to use, the use of, and perceived barriers to IBL), survey data were analyzed using frequencies and percentages to look at teachers' perceptions of IBL and the barriers to its implementation. To answer research question four a Pearson's product moment correlation (r) was conducted to determine if there was a relationship between teachers' intent to use and actual use of IBL in daily lessons. Effect size was measured using the coefficient of determination (r2), both variables are continuous in measurement at a significance of 0.05.

Qualitative:

Qualitative data were obtained from and open-ended questions as part of the modified PRIMAS survey and semi-structured teacher interviews and then analyzed using a thematic analysis. From both the teacher responses to the open-ended question and the transcriptions of the ZOOM recordings, an inductive coding process was used to analyze the qualitative data. To answer research question six, participant data were analyzed for emergent themes using NVivo software, and were recoded to identify patterns and themes. After the transcripts were examined, a color-coding system was used in order to identify the emergent themes. This code was used to describe the relationship between perceptions of teachers related to their intent to use IBL in daily lessons, their actual use IBL in their daily lessons and the major barriers to implementation perceived by the participants. Once the categories were established, codes were reorganized into subcategories and these findings were then recorded, and conclusions were drawn based on the data.

Validity

The qualitative analysis process included validation by using triangulation of individual teacher responses. In order to increase validity, data obtained from the surveys and interviews was compared and cross-checked among participants. The responses received from the interview process were subject to member-checking by having participants review the preliminary results and transcripts in order to enhance the accuracy of the responses provided as well as the researcher’s interpretation of the data. Interview questions were cross-checked by members of the researcher’s thesis committee prior to the interview process, to ensure that the questions allowed the researcher to collect the data needed to answer the research question. The peer reviews served the purpose of obtaining feedback related to questions posed to teachers about their knowledge and use of IBL.

Privacy and Ethical Considerations

The privacy of all participants has been provided to the best of the researcher’s ability. All teachers were given a unique code that was not given anyone other than the researcher and the teacher. This code was used to identify the teacher on all survey and interview materials. The coded material and the key to that code are not stored together. All participants were provided with informed consent letters prior to taking the survey and verbal consent was recorded during the interviews. Participants were informed of their right to back out of the study at any time and/or have part, or all of their data omitted from the study. Students were not included in the data collection of this research project as all survey questions were provided online and interviews were conducted via ZOOM outside of classroom hours. All data is stored in a locked file cabinet in the private office of the researcher. The key to the teacher identification codes is secured in a locked file cabinet in the dissertation chair's office. All data and identifying information will be destroyed after conference of the candidate doctoral degree and the conclusion of this project.

Research Design Limitations

This study consisted of several limitations. First, the inclusion of the perceptions in relationship to intent to implement IBL. Given that a perception is another way to classify an opinion, the perceptions of the teachers who participate in the study cannot be applied to all teachers in the greater Houston area, or the state of Texas. Second, participants varied based on years of teaching experience, training, classes taught, student demographics, and many other factors. During the study, no attempt was made to determine the influence of these variations on teacher perceptions. The results must therefore be applied only to the teachers that participated and not generalized to all teachers.

Third, the level of understanding of the process of inquiry consisted of many factors and could not be assumed to be the same for all teachers or districts based on the interview data collected here. With differing levels of understanding comes differences in opinion of a subject, and IBL is no exception. Also, IBL is often confused with other similar methodologies and therefore we cannot conclusively determine if the teacher's responses are accurate for IBL specifically. Fourth, the survey required teachers to self-report their usage of IBL. No attempt was made to determine if these teachers accurately reported the amount of IBL used. Therefore, the teachers selected to participate in the interview process may not accurately represent the group to which they were selected.

Conclusion

There are many factors that teachers cite when asked about their preferred choice of instructional methodologies, while research repeatedly shows that IBL is an integral aspect of STEM learning (Capps & Crawford, 2012; Colburn, 2000; Walker, 2015), teachers report a preference to sticking to traditional classroom teaching strategies (Anderson, 2011; Au, 2007; Katzmann, 2007; Moon et al., 2003). To that end, this mixed method study is designed to examine teachers' perceptions of the intent to use, its actual use, and the barriers to implementing IBL. By discovering who is using IBL and what barriers prevent its use we can start to develop a picture of how to increase IBL as part of daily lessons in 6-12th grade science. The following chapter will present the data collected in this study.

CHAPTER IV:

RESULTS

The purpose of this study was to examine the perceptions of secondary science teachers to determine their intended use of IBL, their actual use of IBL, and what barriers they perceive are limiting factors between intent and implementation. This chapter presents the findings of the quantitative and qualitative data analysis of the study. First an explanation of the participants' demographics of the study are presented, followed be the results for each of the seven research questions. It concludes with a summary of the findings.

Participant Demographics

One hundred teachers from within Region 4 in Southeast Texas completed the online, Qualtrics survey. Demographic data were voluntarily provided by participants during the survey portion of the study. Of the 100 participants, 72.0% (n=72) were female, 28.0% (n=28) were male, 15.0% (n=15) were African American, 14.0% (n=14) were Hispanic or Latino, 4.0% (n=4) were Asian, 4.0% (n=4) were other races/ethnicities, and 63.0% (n=63) were White. Teachers were also asked to report their subject taught. From the 100 responses 19.0% (n=19) taught middle school, 6-8th grade) science, 32.0% (n=32) taught Biology, 9.0% (n=9) taught Chemistry, 7.0% (n=7) taught Physics, and 33.0% (n=33) reported teaching two or more subjects at the high school level. Table 4.1 specifies the overall participant demographics for teachers completing the Qualtrics survey.

Table 4.1

Survey Participants from Region 4 Texas:

	Frequency (n)	Percent (%)
Female	72	72.0
Male	28	28.0
Caucasian	63	63.0
African American	15	15.0
Hispanic or Latino	14	14.0
Asian	4	4.0
Other Races	4	4.0
Middle School Science	19	19.0
Biology/Life Science	32	32.0
Chemistry	9	9.0
Physics	7	7.0
Two or More Subjects-High School	33	33.0

From the 100 survey participants, six participated in one-on-one interview sessions. Of the six teachers interviewed, 50.0% (n=3) were female and 50% (n=3) were male. The ethnicity of the interviewees is as follows, 33.0% (n=2) were Hispanic or Latino, 17.0% (n=1) were Middle Eastern, and 50% (n=3) were White. Table 4.2 specifies the overall teacher demographics participating in the interview process. Table 4.3 provides the interview participant data: pseudonyms, grouping and courses taught.

Table 4.2

Interview Participants from Region 4 Texas

	Frequency (n)	Percent (%)
Female	3	50
Male	3	50
Caucasian	3	50
Middle Eastern	1	17
Hispanic or Latino	2	33

Table 4.3

Interview Participants Data from Region 4 Texas

Pseudonym	IBL Grouping	Course Taught
Mr. Garcia	High-Use	HS Environmental Science
Ms. Lopez	Low-Use	HS Biology
Ms. Lovato	Low-Use	HS Chemistry
Ms. Nix	High-Use	7^{th} Grade Science
Ms. Perry	High-Use	HS Physics
Mr. Stapleton	Low-Use	HS Integrated Chemistry and Physics

Research Question One

Research question one, To what extent do science teachers intend to use IBL activities in their daily lesson plans?, was answered using frequencies and percentages calculated from the responses to the modified PRIMAS survey. Of the 52-items, 7-items pertained to a teacher's intent to use IBL. For this subset of questions, the survey included a 4-point Likert scale (1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree) and measured science teachers' intent to use IBL in their daily lessons. The Cronbach's alpha for Intent to Use IBL subscale was 0.840. The responses related to teacher intent to use IBL are provided below.

The majority of participants (90.0%) stated that they would like to be more involved in the implementation of IBL related lessons. While only around half reported that they use IBL daily (41.0%) or as part of their routine teaching (58.0%). Most agreed that IBL is well suited to improving students' STEM learning (91.0%) with 78.0% supporting the idea that IBL can also improve student motivation to learn. Table 4.3 displays the frequencies and percentages of teacher responses to the teacher intent to use IBL subset of questions from the survey. Table 4.4 displays the percentages and frequencies of teacher responses from all participants in collapsed form on perceptions related to Intent to Use IBL by survey item.

Table 4.4

Intent to Use IBL

Item A	Strongly Disagree	Disagree	Agree	Strongly Agree
1. I would like to implement more IBL practices in my lessons.	3.0% (n=3)	8.0 % (n=8)	60.0% (n=60)	30.0% (n=30)
2. IBL is well suited to overcome problems with student motivation.	6.0% (n=6)	15.0% (n=15)	60.0% (n=60)	18.0% (n=18)
3. I regularly do projects with my students using IBL.	6.0% (n=6)	36.0% (n=36)	49.0% (n=49)	9.0% (n=9)
4. I would like to do more IBL to enrich my teaching practice.	3.0% (n=3)	6.0% (n=6)	63.0% (n=63)	28.0% (n=28)
5. IBL is part of my daily teaching.	8.0% (n=8)	49.0% (n=49)	33.0% (n=33)	9.0% (n=9)
6. IBL is a well-suited approach to students' learning.	3.0% (n=3)	6.0% (n=6)	67.0% (n=67)	24.0% (n=24)
7. I want to be part of a more coordinated and effective approach to IBL.	1.0% (n=1)	12.0% (n=12)	56.0% (n=56)	30.0% (n=30)

Table 4.5

Collapsed Responses: Intent to Use IBL

Item A	Agree/Strongly Agree	Disagree/Strongly Disagree
1. I would like to implement more IBL practices in my lessons.	89.0% (n=89)	11.0 (n=11)
2. IBL is well suited to overcome problems with student motivation.	79.0% (n=79)	21.0% (n=21)
3. I regularly do projects with my students using IBL	58.0% (n=58)	42.0% (n=42)
4. I would like to do more IBL to enrich my teaching practice.	91.0% (n=91)	9.0% (n=9)
5. IBL is part of my daily teaching.	43.0% (n=43)	57.0% (n=57)
6. IBL is a well-suited approach to students' learning.	91.0% (n=91)	9.0% (n=9)
7. I want to be part of a more coordinated and effective approach to IBL.	86.0% (n=86)	13.0% (n=13)

Research Question Two

Research question two, To what extent do science teachers use IBL in their daily lesson plans?, was answered using frequencies and percentages calculated from the responses to the modified PRIMAS survey. Of the 52-items, 19-items pertain to the types of activities and student participation. For this subset of questions, the survey included a 4-point Likert scale (1=never or hardly ever, 2=in some lessons, 3=in most lessons, 4=in almost all lessons) and measured science teachers' intent to use IBL in their daily lessons.

Fewer than half (41.0%) of the teachers self-reported using IBL in their daily lessons. The following questions give a better indication of the types of lesson and the actual use of IBL based on the responses to subset B. The Cronbach's alpha for the Use of Inquiry subscale is 0.909. These survey responses are provided below.

One of the key components of open inquiry is student choice when designing investigations and learning (Bell, 2010; Capps & Crawford, 2012; Feyioglu, 2019; Walker, 2015). Based on the responses to the survey, less than one third of the teachers surveyed (28.0%) stated that student choice was involved in the majority of lesson plans, while more than half (58.0%) state that students followed teacher's instructions in their daily lesson. Regarding a hands-on approach to learning, often mistaken for IBL, less than half (45.0%) of teachers claimed that students experiment in most daily lessons and about one-third (38.0%) stated that students repeatedly use the same methods to answer questions in their daily lessons. Slightly more than half of teachers (58.0%) state that student work is related to real world experiences in daily lessons. Regarding student participation, most teachers (71.0%) state that students are involved in class debates and discussions during most daily lessons. Table 4.5 displays the frequencies and percentages of teacher responses to the teacher use of IBL subset, while Table 4.6 displays the percentages and frequencies of teacher responses from all participants in collapsed form on perceptions related to use of IBL by survey item.

Table 4.6

Use of IBL

Item B	Never or Hardly Ever	In some Lessons	In Most Lessons	In Almost All Lessons
In my classroom, the students:				
1…are given opportunities to explain their ideas.	2.0% (n=2)	24.0% (n=24)	49.0% (n=49)	25.0% (n=25)
2…spend time doing practical experiments/investigations.	8.0% (n=8)	47.0% (n=47)	34.0% (n=34)	11.0% (n=11)
3 ...have the possibility to try their own ideas.	13.0% (n=13)	50.0% (n=50)	27.0% (n=27)	10.0% (n=10)
4 ...do experiments/investigations by following my instructions.	4.0% (n=4)	43.0% (n=43)	42.0% (n=42)	11.0% (n=11)
5. ...repeatedly practice the same method on many questions.	13.0% (n=13)	49.0% (n=49)	25.0% (n=25)	13.0% (n=13)
6. ...have discussions about the topic.	3.0% (n=3)	28.0% (n=28)	36.0% (n=36)	33.0% (n=33)
7. ...learn through doing exercises.	2.0% (n=2)	26.0% (n=26)	51.0% (n=51)	21.0% (n=21)
8. ...draw conclusions from experiments/investigations they have conducted.	6.0% (n=6)	36.0% (n=36)	36.0% (n=36)	22.0% (n=22)
9...design their own experiments/investigations.	31.0% (n=31)	51.0% (n=51)	12.0% (n=12)	6.0% (n=6)
10...have the possibility to decide how things are done during the lesson.	20.0% (n=20)	52.0% (n=52)	18.0% (n=18)	10.0% (n=10)

11...do experiments/ investigations to test their own ideas.	35.0% (n=35)	44.0% (n=44)	13.0% (n=13)	8.0% (n=8)
12. ...are involved in class debate/discussion.	8.0% (n=8)	25.0% (n=25)	47.0% (n=47)	20.0% (n=20)
13...have the chance to choose their own experiments/investigations.	31.0% (n=31)	47.0% (n=47)	15.0% (n=15)	7.0% (n=7)
14...work on problems that are related to real life experiences.	5.0% (n=5)	37.0% (n=37)	43.0% (n=43)	15.0% (n=15)
15...start with easy questions and move onto harder questions.	4.0% (n=4)	17.0% (n=17)	54.0% (n=54)	22.0% (n=22)
16...have influence on what is done in the lesson.	13.0% (n=13)	55.0% (n=55)	29.0% (n=29)	3.0% (n=3)
17...chose which questions to do or which ideas to discuss.	19.0% (n=19)	54.0% (n=54)	24.0% (n=24)	3.0% (n=3)
18...are informed about the aim of the lesson.	2.0% (n=2)	8.0% (n=8)	43.0% (n=43)	47.0% (n=47)
19...do experiments/investigations that can be done/answered using more than one method	16.0% (n=16)	42.0% (n=42)	29.0% (n=29)	13.0% (n=13)

Table 4.7

Collapsed Responses: Use of IBL

Item B.	Never/Hardly Ever/In Some Lessons	In Most/almost All Lessons
In my classroom, the students:		
1…are given opportunities to explain their ideas.	26.0% (n=26)	74.0% (n=74)
2…spend time doing practical experiments/investigations.	55.0% (n=55)	54.0% (n=45)
3 ...have the possibility to try their own ideas.	63.0% (n=63)	37.0% (n=37)
4 ...do experiments/investigations by following my instructions.	47.0% (n=47)	53.0% (n=53)
5. ...repeatedly practice the same method on many questions.	62.0% (n=62)	38.0% (n=38)
6. ...have discussions about the topic.	32.0% (n=32)	68.0% (n=68)
7. ...learn through doing exercises.	28.0% (n=28)	72.0% (n=72)
8. ...draw conclusions from experiments/investigations they have conducted.	42.0% (n=42)	58.0% (n=58)
9...design their own experiments/investigations.	82.0% (n=82)	18.0% (n=18)
10...have the possibility to decide how things are done during the lesson.	72.0% (n=72)	28.0% (n=28)
11...do experiments/investigations to test their own ideas.	79.0% (n=79)	21.0% (n=21)

12. ...are involved in class debate/discussion.	33.0% (n=33)	67.0% (n=67)
13...have the chance to choose their own experiments/investigations.	78.0% (n=78)	22.0% (n=22)
14...work on problems that are related to real life experiences.	42.0% (n=42)	58.0% (n=58)
15...start with easy questions and move onto harder questions.	21.0% (n=21)	76.0% (n=76)
16...have influence on what is done in the lesson.	88.0% (n=88)	32.0% (n=32)
17...chose which questions to do or which ideas to discuss.	73.0% (n=73)	27.0% (n=27)
18...are informed about the aim of the lesson.	10.0% (n=10)	90.0% (n=90)
19...do experiments/investigations that can be done/answered using more than one method	58.0% (n=58)	42.0% (n=42)

Research Question Three

Research question three, To what extent do science teachers perceive barriers as limiting their use of IBL in their daily lesson plans?, was answered using frequencies and percentages calculated from the responses to the modified PRIMAS survey. Of the 52-items, 22-items pertain to Teacher's Perceived Limitations. This subset is divided into two subscales, C with 13-items, and D with 9-items on the survey. For this subset of questions, the survey included a 4-point Likert scale (1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree) and measured science teacher's perceived limitations to the use of IBL in their daily lessons. The combined Cronbach's alpha for Limitations to the

Use of IBL was 0.846. The responses related to teachers' perceived limitations to use IBL are provided below.

There are multiple factors that can limit how and when IBL is implemented. According to the survey results, the two biggest limitations to IBL are time constraints and assessments that do not reward IBL. Based on the survey 66.0% of teachers stated that time concerns are a limiting factor, and 62.0% stated that how assessments are constructed discourages their implementation of more IBL. Lack of a curriculum that encourages IBL was reported by 60.0% of teachers, and 50.0% reported that their district did not encourage changes to curriculum. Lack of adequate materials to implement IBL in more daily lessons was a concern of 56.0% of respondents.

Other areas that can limit IBL were less of a concern for the teachers that participated in this study. Student discipline was only considered a limiting factor by 30.0% of teachers, however 53.0% responded that they felt students would "get frustrated or lost" in the process of IBL. The majority of teachers (78.0%) stated that they were aware of the principals of IBL, while access to suitable continued education (training) programs was considered a limiting actor by 55.0% of teachers, only 34.0% reported a lack of confidence in their current ability to teach using IBL. Table 4.7 displays the frequencies and percentages of teacher responses to the teacher's perceived limitations subset of questions from the survey. Table 4.8 displays the percentages and frequencies of teacher responses from all participants in collapsed form on perceptions related to Limitations to Use of IBL by survey item.

Table 4.8

Responses to Limitations to the Use of IBL by Survey Item

	Strongly Disagree	Disagree	Agree	Strongly Agree
Item C: I have difficulties in implementing IBL, because:				
1...the curriculum does not encourage IBL.	5.0% (n=5)	35.0% (n=35)	51.0% (n=51)	9.0% (n=9)
2...I have a lack of adequate teaching materials.	8.0% (n=8)	36.0% (n=36)	46.0% (n=46)	10.0% (n=10)
3...IBL is not included in the textbooks I use.	10.0% (n=10)	30.0% (n=30)	44.0% (n=44)	16.0% (n=16)
4....I don't know how to assess IBL.	18.0% (n=18)	46.0% (n=46)	32.0% (n=32)	4.0% (n=4)
5...I don't have access to adequate CPD programs involving IBL.	8.0% (n=8)	37.0% (n=37)	48.0% (n=48)	7.0% (n=7)
6...I worry about student's discipline being more disruptive in IBL lessons.	26.0% (n=26)	40.0% (n=40)	29.0% (n=29)	5.0% (n=5)
7...I don't feel confident in IBL.	25.0% (n=25)	41.0% (n=41)	27.0% (n=27)	7.0% (n=7)

8 ...I am worried about my students getting lost or frustrated in their learning.	16.0% (n=16)	30.0% (n=30)	44.0% (n=44)	10.0% (n=10)
9....I think that group work is difficult to manage.	33.0% (n=33)	47.0% (n=47)	15.0% (n=15)	5.0% (n=5)
10...there is not enough time in the curriculum.	9.0% (n=9)	31.0% (n=31)	34.0% (n=34)	26.0% (n=26)
11....I don't have sufficient resources, such as computers, lab equipment.	15.0% (n=15)	33.0% (n=33)	35.0% (n=35)	17.0% (n=17)
12...my students have to take assessments that don't reward IBL.	10.0% (n=10)	23.0% (n=23)	36.0% (n=36)	31.0% (n=31)
13....the school system does not encourage changes.	14.0% (n=14)	3.07% (n=37)	31.0% (n=31)	18.0% (n=18)
Item D: Knowledge and Concerns of IBL use:				
1…I have spent some time thinking about IBL.	3.0% (n=3)	13.0% (n=13)	60.0% (n=60)	24.0% (n=24)

2…I know about the principals of IBL.	4.0% (n=4)	16.0% (n=16)	60.0% (n=60)	20.0% (n=20)
3…I know about the immediate requirements of using IBL.	3.0% (n=3)	29.0% (n=29)	56.0% (n=56)	12.0% (n=12)
4…I am concerned about the time and energy required for implementing IBL.	6.0% (n=6)	22.0% (n=22)	46.0% (n=46)	26.0% (n=26)
5…I am concerned that I cannot manage all that IBL pedagogies require of me as a teacher.	10.0% (n=10)	50.0% (n=50)	35.0% (n=35)	5.0% (n=5)
6…I am concerned about the tension between IBL and effectively preparing students for exams.	10.0% (n=10)	30.0% (n=30)	42.0% (n=42)	18.0% (n=18)
7…I am concerned that preparing IBL lessons takes extra time.	7.0% (n=7)	31.0% (n=31)	43.0% (n=43)	19.0% (n=19)

8…I am concerned about students' attitudes toward IBL.	14.0% (n=14)	45.0% (n=45)	32.0% (n=32)	9.0% (n=9)
9…I am concerned about the effects of IBL teaching on students' performance overall.	16.0% (n=16)	40.0% (n=40)	37.0% (n=37)	7.0% (n=7)
10…I am concerned that classroom management of IBL is difficult.	23.0% (n=23)	43.0% (n=43)	27.0% (n=27)	7.0% (n=7)

Table 4.9

Collapsed Responses: Limitations to the Use of IBL

	Strongly Disagree/Disagree	Agree/Strongly Agree
Item C: I have difficulties in implementing IBL, because:		
1...the curriculum does not encourage IBL.	40.0% (n=40)	60.0% (n=60)
2...I have a lack of adequate teaching materials.	44.0% (n=44)	56.0% (n=66)
3...IBL is not included in the textbooks I use.	40.0% (n=40)	60.0% (n=60)
4....I don't know how to assess IBL.	64.0% (n=64)	36.0% (n=36)
5...I don't have access to adequate CPD programs involving IBL.	45.0% (n=45)	55.0% (n=55)
6...I worry about student's discipline being more disruptive in IBL lessons.	66.0% (n=66)	34.0% (n=34)
7...I don't feel confident in IBL.	66.0% (n=66)	34.0% (n=34)
8 ...I am worried about my students getting lost or frustrated in their learning.	46.0% (n=46)	54.0% (n=54)
9....I think that group work is difficult to manage.	80.0% (n=80)	20.0% (n=20)
10...there is not enough time in the curriculum.	40.0% (n=9)	60.0% (n=60)

11....I don't have sufficient resources, such as computers, lab equipment.	48.0% (n=48)	52.0% (n=52)
12...my students have to take assessments that don't reward IBL.	33.0% (n=33)	67.0% (n=67)
13....the school system does not encourage changes.	51.0% (n=51)	49.0% (n=49)
Item D: Knowledge and Concerns of IBL use:		
1…I have spent some time thinking about IBL.	26.0% (n=26)	84.0% (n=84)
2…I know about the principals of IBL.	20.0% (n=20)	80.0% (n=80)
3…I know about the immediate requirements of using IBL.	31.0% (n=31)	69.0% (n=69)
4…I am concerned about the time and energy required for implementing IBL.	28.0% (n=28)	72.0% (n=72)
5…I am concerned that I cannot manage all that IBL pedagogies require of me as a teacher.	60.0% (n=60)	40.0% (n=40)
6…I am concerned about the tension between IBL and effectively preparing students for exams.	40.0% (n=40)	60.0% (n=60)
7…I am concerned that preparing IBL lessons takes extra time.	38.0% (n=38)	62.0% (n=62)

8…I am concerned about students' attitudes toward IBL.	59.0% (n=59)	41.0% (n=41)
9…I am concerned about the effects of IBL teaching on students' performance overall.	57.0% (n=57)	43.0% (n=43)
10…I am concerned that classroom management of IBL is difficult.	66.0% (n=66)	34.0% (n=34)

Research Question Four

Research question four, Is there a relationship between science teachers' intent to use IBL and the use of IBL in daily lessons?, was answered using a Pearson's Product Moment Correlation (Pearson's r) by comparing responses to Intent to Use IBL and Use of IBL from the modified PRIMAS survey. The results of the Pearson's r indicated that there was statistically significant positive relationship between teachers' intent to use IBL and their reported use of IBL in their daily lessons ($r = .495$, $p = .01$, $r2=.245$). As the teacher's intent to use IBL increases, the actual use of IBL increases. Approximately 24.5% of the variance in the use of IBL in daily lessons can be attributed to teachers' intent to use IBL.

Research Question Five

Research question five, How well do science teachers understand the concept of IBL?, was addressed by using a qualitative inductive coding process. In research question three, 78% of teachers self-reported as understanding the principals of ILB. In an attempt to better understand teacher responses to the PRIMAS survey items, an open-ended question was added; "In your own words, please define Inquiry-Based Learning?" to the survey. Of the 100 teachers to take the survey, 81 provided a response to this question. In reviewing the answers provided the following themes emerged: (a) the teacher cannot define IBL, (b) teachers act as facilitators, (c) students are in control of learning, and (d) students are given questions. For each subtheme, perspectives are presented below followed by a sample of the teachers' definitions.

The Teacher Cannot Define IBL

When asked to provide a definition of IBL, a small number, 11.0% (n=9), of the 81 total respondents could not provide an adequate or accurate definition of IBL. Four of the nine teachers did not provide a definition of IBL. Two of the four teachers provided only one-word answers that cannot be considered as definitions and two teachers stated that they did not know about IBL. For example, one high school technology teacher was unsure what IBL was: "I am really not sure what it [IBL] is." Another teacher with experience in biology and Earth sciences, responded "I don't know. [I] never had any experience with it [IBL]."

The remaining five teachers from this subtheme provided definitions that are either incomplete or inadequate to encompass the complexity of IBL. Of these five, three teachers used hands on learning as the basis of IBL. For example, one sixth-grade science teacher's definition does not fully describe the scope of IBL responding that IBL is "hands on learning." Similarly, one middle school science teacher fails to encompass the complexity of IBL, defining it as "learning that provides intellectual stimulation" but does not elaborate as to how this occurs with IBL as opposed to any other learning stye. Another high school science teacher, teaching multiple subject areas, also fails to encompass the complex nature of IBL, simply stated that IBL is "Learning by doing." One teacher provides a definition that was incomplete. This AP environmental science teacher gave a partial definition stating, "kids design the experiment." However, this is only one aspect of the nature of IBL.

Teachers act as Facilitators

Of the 81 teachers to provide a definition of IBL, another 11.0% (n=9) were able to define the role of the teacher as a facilitator to student learning. In this way teachers allow students to be responsible for the discovery of their own knowledge. All nine of these respondents use the term facilitator as part of their definition to of IBL, either directly or indirectly. Three of the nine teachers directly reference the teacher as the facilitator. For example, an aerospace science teacher gave a meaningful example of how facilitations works when he stated, “Teachers are facilitators. The students set up their own experiments to solve problems or conduct their own research to answer a question.” Other teachers use a more indirect way of describing teacher facilitators. For example, an aquatic science teacher gave a definition of the process of facilitation when they stated, “Teachers act as a guide rather than [providing] direct instruction.” Another high school biology teacher defines teacher facilitation as part of IBL by stating that, “Students lead the learning with questioning and discovery. Teacher moderates or prompts learning and guides students.” These answers were typical for all teachers represented in this subtheme.

Students are in Control of Learning

Of the 81 teachers responding, 17.0% (n=14) defined IBL as a type of learning that is student led. Definitions in this subtheme include teacher responses that use student control and student ownership as essential parts of IBL. The following examples are representative of the definitions of the 14 teachers who responded in this manner. One response from a seventh-grade science teacher explained student control in learning as, “Students work with a question in mind and are typically design their own investigation, or are guided through investigation choices, to try to learn about the question they start with." Or, as another high school biology and research design teacher described the process of IBL through the lens of student control as:

> For example, my […] class used to include an environmental health unit. After introducing the major concepts with the content students had to choose a topic that interests them about environmental health and develop a question that could be tested through experimentation, explain the design or experiment, and methods, set up and conduct the experiment, collect, analyze, and present the entire process in a presentation to the class. At each step, the students had to get approval before moving to the next step, but the approval process didn't involve yes or no questions and explanations from me, it was more open-ended, and if I foresaw a problem with the design or methods, I didn't just tell the students, I asked them open-ended questions that guided their understanding, or made them do more research in the process (personal communication, January 2021).

Another way that student control can be expressed is through student ownership of learning. For example, one high school biology teacher described the process of student ownership in IBL by stating, "IBL is giving students the opportunity to discover the nature of science through their own questioning and exploration. It gives ownership to the student over their own learning. It makes what they are learning engaging and relevant." Or, as one chemistry teacher puts described student ownership in IBL, "Inquiry-based learning is a method of student ownership of the content taught in science. It gives a real-world problem to define and solve."

Students are Given Questions

Another way in which IBL was defined is as the use of questions to guide student learning. Of the 81 teachers who defined IBL 44.0% (n=36) refer to IBL as a way in which students answer questions. The following responses are representative of the types of answers teachers in this subtheme gave in defining IBL. For example, one of the biology teachers claimed that in performing IBL, “Students develop their own questions/ideas about a topic and then are guided to find out of the box answers or solutions through research and experimentation when possible.” Similarly, one seventh-grade science teacher defined problem solving in IBL as “Questioning and problem-solving to where the student is able to use hands-on experiences to master the ideas and content.” Another use of problem solving in the defining of IBL comes from an environmental science and forensics teacher, who stated that IBL is “A learning practice where questions or questioning or a problem is used to guide the learning process more deeply.”

Research Question Six

Research question six, *How do science teacher perceptions impact their daily use of IBL?*, was addressed by using a qualitative inductive coding process. In an attempt to capture a more in-depth understanding of the influence that teacher perceptions of IBL have on their use of IBL in their daily lessons, six teachers total (three who stated they use IBL routinely and three who stated they seldom use IBL in their daily lessons) were interviewed regarding their current teaching practice, their perceptions of IBL, and their perceived limitations for the amount of IBL implemented in their daily lessons. From the major themes identified the subthemes: (a) teacher driven instruction, (b) student driven instruction, (c) benefits of IBL, and (d) limitations to inquiry were identified based on teacher responses. For each subtheme, perspectives are presented below followed by a sample of the teachers’ responses.

Teacher Driven Instruction

Three of the six participants (50.0%) in the interview process claimed to use little to no IBL in their daily lessons in their survey responses. These teachers also reported a high amount of teacher driven instruction. This level of instruction includes note taking, skill-based activities, and teacher driven inquiry activities (Structured Inquiry, in which the student is given a problem to solve, the methods to solve it, and the teacher knows the outcome of the activity ahead of time). Teachers that use these methods often begin a lesson with a demonstration or activity that is meant to introduce students to the topic to be covered. Ms. Lovato claimed that teacher driven instruction is typical in the introductory process when she stated, “we would start a unit usually out with a lab that introduces the students to the topic and the labs are usually guided.” Mr. Stapleton’s classroom is also based on a teacher-centered instruction and uses a more direct explanation, stating, “I need to directly teach right, I need to lecture I need to explain.”

When asked to discuss the distribution of IBL in their lessons, these teachers claimed to focus on teacher led Structured Inquiry. For example, Ms. Lopez explained that their students are told:

> Here's how you're going to do it [the activity], here's everything you need, and this is what you're supposed to get at the end, so I feel like that is, the majority of what I use in my classroom.

Ms. Lovato emphasized that her student makeup influenced her use of Structured Inquiry in the following way: “I was teaching below level students so I would say 90% [of inquiry] was structured.” Ms. Lopez felt similarly about student ability and inquiry saying, “I think it's cognitive ability [of students] and I think it's their background knowledge and what they aren’t prepared to do.”

Student Centered Instruction

Three of the six teachers (50.0%) interviewed were considered to have a high use of IBL based on their responses to the survey. These teachers describe their lessons as being more student driven, and less teacher directed. The teachers in this subgroup did not discuss students as note takers, or activities as being task driven. Instead, teachers claimed that their students directed their own learning, and that activities were more open ended, with less predictable results than those given by the low inquiry group. For example, Mr. Garcia described his classroom as being heavily focused on student-centered earning when he stated:

> I like to come in with a topic and let my kids explore it on their own. I only really get involved if they're not getting motivated or they're kind of going down the wrong road with it like where I don't want them to go. Otherwise, I really like to let them do the discovery on their own find things that interest them about what we're talking about and let them tie that in. I find that I get better result when they have some sort of ownership of the material, other than [saying] hey here's what the state says I [have to] teach you, let's go through A, B, C, and D. (direct communication, April 2021)

Ms. Perry's description of her classroom and its use of student-centered learning included the following statement:

> I hook them somehow and then I put equipment in front of them to make observations. And then, based on those observations, they tell me what they think, and I start to attach vocabulary, or we graph [the data] and we get some kind of equation that we can use that then we apply [this information] to a new situation. (direct communication, April 2021)

The response from Ms. Nix includes a traditional lesson planning methodology when including student-centered learning in the classroom. She describes her teaching by saying: “We follow the Five-E, engage, explore, explain, I open my class every day with a warmup trying to get them thinking about what we're learning, or I fit background knowledge into what we're about to do.”

These teachers also report using more open-ended types of learning. These teachers reported using Guided Inquiry (students use their own methods to solve a given problem) or Open Inquiry (students develop a question and then solve it using their own methods) more than 50% of the time in their lesson planning. Guided Inquiry dominates for these teachers. For example, when asked about how often guided inquiry was part of typical lesson planning, Ms. Nix said, “I’m probably there 60% of the time.” While the use of Open Inquiry is less frequent with all three teachers claiming to use this about 20% of the time in lesson plans. Mr. Garcia explained his reasons to limit IBL when he said:

> I just have some classes, they can't handle that kind of autonomy like I can't depend on them to come up with something to research, a plan to do it and then actually execute it like they they'll just get distracted or off topic really fast. (direct communication, April 2021)

While high-use teachers agree that inquiry is typically the best method for instruction in the science classroom, statements like these demonstrate that even for these teachers there are times that IBL is difficult to implement.

Perceptions of IBL

Teachers from both the Low-IBL Use and High-IBL Use groups have positive perceptions of IBL. Teachers were asked “Are there any benefits to IBL? If so, what?” Responses to this question varied, but 100% of teachers began by saying that there were some benefits to IBL.

The Low-Use group saw the benefits in terms of greater student understanding and analysis. For example, when discussing the retention of materials while using IBL Ms. Lovato stated, “students retain the material a lot more and when working with students from a lot of different backgrounds, I feel that it's helped kind of even the playing field.” Similarly, Ms. Lopez emphasized the benefits of critical thinking involved in IBL when she stated, “I think there's a lot of benefits when it comes to it. First off it helps the kids use their critical thinking skills.” Mr. Stapleton felt that IBL was beneficial depending on the goal of the learner but was also difficult to manage in terms of the standards placed on him by the state, he stated:

> If your goal is to try to train future scientists., then I think there may be some benefit in IBL. Be it from the way I understand it to be, but I don't know how you do that and meet TEKS. (personal communication, April 2021)

This frustration with state standards and its impact on teacher ability to conduct IBL was common for the teachers who identify as Low-Use.

Teachers who are classified into the High-Use group had a high perception of IBL and were able to elaborate more on the benefits to both students and teachers. Their use of IBL in the classroom gave them a slightly different opinion as seen in the comments from the Low-Use group. Since these teachers routinely use IBL, they possibly have a better understanding of the benefits. The comment from Ms. Perry showed this higher level of understanding and a greater positive perception of IBL when she stated:

> You learn through inquiry, everything else is someone forcing something down your throat, and it doesn't stick, and you don't understand it, and you don't take ownership of it and you don't really know it. So, inquiry is the only way, in my opinion, to learn. (personal communication, April 2021)

Similarly, when asked about if there are benefits to IBL Mr. Garcia expressed his thoughts in a very positive manner about the benefits of IBL and its impact on students when he explained:

> I fight for it [IBL] on my campus all the time, so that it is across more than just my class and curriculum. IBL benefits our kids who take ownership, so they are they're more invested in what we're doing and what we're learning. I end up with higher test scores, as a result. One of my things is doing it [IBL] this way is I can ask bigger questions and my kids and I can have better conversation, instead of just saying okay we'll explain A and B and C. I don't need the definitions, I can ask my class, why did something happen, and what would happen if we change this, or what would happen if we change that, which is, you know that little bit of critical thinking that we can take a step further, which makes my job, a lot more fun and interesting. (personal communication, April 2021)

Ms. Nix shares a similar perception of the goals and benefits of IBL in preparing students to be self-directed learners when she described the following:

> I think it promotes the critical thinking skills that's lacking in kids now. We're trying to build them up to where they can have the tools to help them figure out how to solve problems, how to be creative enough to create their own labs to solve their own problems or come up with their own questions. (personal communication, April 2021)

These comments demonstrate an overall high perception of IBL and come from teachers experienced in its implementation in the classroom.

Regardless of use, and general understanding teachers who participated in the interview process had positive perceptions of IBL even when asked to explain the negatives of IBL use. Both the Low-Use and High-Use groups of teachers focused on the lack of knowledge or time. For example, Ms. Lopez stated that lack of knowledge is a barrier by when she said, “I don't think there's any negatives, I think it's more of just understanding how to do it.” Ms. Lovato claimed, “there's more time involved in the prep and [IBL] takes up more time with the curriculum.” High use teachers were also critical of the time involved. Ms. Perry, a High-Use teacher described comments from her co-workers when she stated, “I will tell you one of the negatives that I hear about it, is that it takes longer.” While Mr. Garcia was more concerned with resources, stating that:

> Not really a negative to using it, the biggest issue I’ve had is just coming up and modifying all of my curriculum and my teaching technique, to do that it's taking me a couple years. Just because there's not a lot of resources out there for people in environmental sciences that are inquiry based so I’m creating a lot of it from scratch. (personal communication, April 2021)

These answers are representative of the responses from the six participants. They demonstrate that high perceptions are only part of the solution to implementation of IBL in daily lessons.

Factors Limiting IBL Implementation

Teachers were asked *Are there any limitations to implementing IBL in your classroom? If so, what*? The six teachers were from different subjects, had different levels of experience, and were in different districts. As a result, their limitations to implementation were mostly unique to their own situations. Classroom management was the area of least concern among teachers interviewed in this study. Teachers in the High-Use group instead reported that student behavior and work ethic was a benefit. Mr. Garcia, for example, describes his students work ethic as:

> It frustrates a lot of administrators that come into my room because they see me with my feet up on my desk, but my kids are grinding away putting stuff on the board right on the computers sending me emails or going, you know hey we found it we're good and I'm just given a thumbs up because it's really hard to evaluate [IBL], like what is he doing? [I'm] like, go ask my kids they'll tell you what they're doing. (personal communication, April 2021)

While not making the same claims, the other teachers in the High-Use group did agree with Mr. Garcia's perception of students being fully engaged in learning.

The "biggest" limiting factor as reported in this study was the time commitment required for IBL implementation. For example, when asked to discuss the limitations to implement IBL Mr. Stapleton stated that the limits were "the time to do [IBL] and the flexibility, I guess, in the curriculum to do it." Ms. Perry also stated that time constraints were an issue when she stated, "the timeline [is a limit] too, because some of the great inquiry projects need a broader timeline." Ms. Nix also felt that the biggest limiting factor to implementing IBL in daily lessons was the time required. She explained her concerns with time saying:

> I think a factor that would hold me back from inquiry is time, because we have to get through the standards as set before us, we have to do certain things and get through all that we want them to know. And the district gives us a particular standard, or this particular assignment, and it must be at this time, and you have this many days. (personal communication, April 2021)

These three examples are representative of the feeling for all six teachers. All six of the teachers who were interviewed, regardless of the level of IBL use in the classroom, discussed similar concerns over time limits.

Student ability or familiarity with inquiry was also noted by these teachers. For example, Ms. Perry discussed student ability stating, “the biggest limiting factor that I’ve experienced is the students experience with inquiry if they're coming from a traditional teacher.” Ms. Lovato had a similar experience which she described when she stated, “if you have students that are on opposite spectrums as far as their level of learning, that has really limited running the whole process smoothly.”

Summary of the Findings

Overall, teachers report a positive perception of IBL regarding its benefits to 6-12th grade science learning. These results come from responses to both the PRIMAS survey, and the individual interviews conducted with study participants. Although teachers demonstrated a high opinion of IBL, the actual use of IBL was divided, with approximately 50% of teacher claiming to use IBL routinely, while 50% claim to use IBL rarely or never. This division in the use of IBL is also representative of both teacher understanding of IBL, teachers’ perceived barriers to IBL, and teachers’ intent to implement IBL. Our findings show that withing Region 4, there is at least an implicit knowledge of the principals of IBL and its use in daily lessons. More importantly, findings also demonstrate that there is a correlation between the intent to use IBL and its actual use in daily lessons. While there are many limitations reported, teachers felt that time and student ability were the biggest factors to limit their ability to implement IBL. The finding that teacher from both the High-Use and Low-Use groups shared similar limitations to implementation further emphasizes the finding that teacher implementation is a result of intent, and not just tied to perception of IBL or the barriers to IBL.

Conclusion

This chapter presented the analysis of qualitative and quantitative data collected from surveys and interviews, participant demographics, and processes of answering each research question. This included the results of the survey and the six participants selected for interviews for elaboration. In the next chapter, findings from this study are compared with existing literature. Additionally, the implications of this study's results will be discussed with consideration toward the influence teacher perceptions and intent play in the implementation of IBL in teacher's daily lessons. Avenues for future research will also be specified.

CHAPTER V:

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

The purpose of this study was to examine the perceptions of secondary science teachers to determine their intended use of IBL, their actual use of IBL, and what barriers they perceive are limiting factors between intent and implementation. Teacher perceptions of IBL is well documented (Anderson, 2011; Englen et al, 2013, Wallace & Kang, 2004). Along with research into the perceived barriers to IBL (Anderson, 2011; Au, 2007; Englen et al., 2013; Roehrig & Luft, 2004; Schoenfeld & Kilpatrick, 2013; Tofel-Grehl & Callahan, 2017; Wallace & Kang, 2004). However, the effect of teacher perception of teaching styles impacts their intent to use best practice, and their actual use those practices in daily lessons has been minimally explored (Nespor, 1987; Marshall & Drummond, 2006; Tofel-Grehl & Callahan, 2017). Most of this research has been based on teacher perception of student learning or of student abilities, while none of the research available has been centered on the perceptions and use of IBL specifically.

To quantify teachers' intent to use IBL, its actual use, and teacher perceived barriers to IBL, a modified version of the PRIMAS Survey was distributed to all 6-12th grade science teachers within Region 4, located in southeast Texas. From this ESC, 100 teachers completed the survey. Participant responses were analyzed to address research questions one through four. Additionally, from the 100 participants, 81 provided their perceived definition of IBL, these 81 responses were analyzed to answer research question five. Finally, six teachers (three self-reported as high IBL use, and three self-reported as low IBL use) participated in semi-structured interviews that allowed the researcher to gain qualitative data pertaining to how these teachers use of IBL was influenced by their intent to use and perceived barriers to use. Within this chapter, the findings of this study are contextualized in the larger body of research literature.

Implications for teachers as well as recommendations for future research are also included.

Summary

The research questions addressed teacher's perceptions on the intent to use, the use of, and the barriers to implementing IBL. The following questions guided this study:

1. To what extent do science teachers intend to use IBL activities in their daily lesson plans?
2. To what extent do science teachers use IBL in their daily lesson plans?
3. To what extent do science teachers perceive barriers as limiting their use of IBL in their daily lesson plans?
4. Is there a relationship between science teachers' intent to use IBL and the use of IBL in daily lesson plans?
5. How well do science teachers understand the concept of IBL?
6. How do science teacher perceptions impact their daily use of IBL?

Research Question 1

Research question one was answered using frequencies and percentages of responses to the PRIMAS survey, which required participants to rate statements on a scale of 1 – 4 (one representing Strongly Disagree and four representing Strongly Agree) based on their intent to use IBL and reported use of IBL. Previous research has suggested that teachers will teach in a manner that best reflects their opinions of how their students should be taught (Nespor, 1987). Therefore, teacher intent to use IBL is a key factor in is overall acceptance in the classroom.

Research question one showed that teachers, overall, had a positive perception of IBL, responding that IBL was a good motivating factor in student learning and was well suited to learning in general. Teachers also expressed a desire to implement more IBL across their daily lessons. These findings are consistent with prior research that has demonstrated that IBL is perceived by teachers as being well suited to student learning in STEM subjects (Anderson, 2011; Englen et al., 2013, Wallace & Kang, 2004).

The data also shows that less than half of participating teachers use IBL routinely. This was based on teachers self-reported use of IBL. Again, these findings are similar to findings that, even when teachers understand or believe that other methodologies are better, something prevents these teachers from enacting best practice in the classroom (Anderson, 2011; Au, 2007; Harrison, 2015; Marshall & Drummond, 2006; Robertson & Elliott, 2018; Wallace & Kang, 2004; Zohar & Agmon, 2018). In these previous studies, the teacher perceptions were assessed in terms of their beliefs in the concepts of IBL and their intent to implement IBL in the classroom. In this study we address the perceptions in terms of how teachers view the concepts of IBL and how it impacts their actual implementation of IBL in their daily lessons.

Research Question 2

Research question two was answered using frequencies and percentages of responses to the PRIMAS survey, which required participants to rate statements on a scale of 1 – 4 (one representing Never and four representing In Almost All Lessons) based on their use of IBL in their daily lesson plans. This subset of questions asked teachers to express how often they conducted different types of activities in the classroom. The data from research question two was designed to elaborate upon the self-reported use of IBL from the question subset reported in research question one.

Based on the responses to the survey, the majority of teachers state that their students participated in some form of class debate or reporting of opinions. However, less than one-third of teachers stated that students had a choice of what to study or the methods used in daily lessons and half of the teachers reported that students followed direct instruction in almost all lessons. One of the major components of IBL is student centered learning. These findings support previous research, in that most science instruction is teacher driven and lacks many components of IBL (Englen et al., 2013; Capps & Crawford, 2012; Dorier & Garcia, 2013).

Another finding of this study is that the majority of the teachers' state that their teaching involves problems based on real-world examples. Real world examples have been shown to help promote student learning by making concepts more real. This is contrary to the reports in previous studies where teachers were found to teach mostly vocabulary. These studies found that teachers also did not engage in real-world analysis or comparisons (Capps & Crawford, 2012; Marshall & Drummond, 2006; Marshall, 2010; Robertson & Elliot, 2018). While we cannot determine the actual level of IBL being implemented, we can conclude that teachers have a high perception of IBL and are attempting to implement some form of IBL in their lessons.

Another component of IBL is the use of independent research, or student-developed projects that explore the subject in a manner similar to that used by practicing scientists (Capps & Crawford, 2012; Colburn, 2000; Walker, 2015). Based on the data from this study, less than half of the teachers reported that students did experiments in daily lessons, and approximately one-third of teachers reported using repetitive problem-solving in most of their daily lessons. For these teachers, the findings of this study are like that of previous research (Harrison, 2015; Roehrig & Luft, 2004). However, we see that approximately two-thirds are attempting to use varying methods in their daily lessons. They are not just sticking to repetition as seen in these previously mentioned studies.

Research Question 3

Research question three was answered using frequencies and percentages of responses to the PRIMAS survey, which required participants to rate statements on a scale of 1 – 4 (one representing Strongly Disagree and four representing Strongly Agree) based on their perceived limitations to implementing IBL in their daily lesson plans. This subset of questions asked teachers to express how different factors impacted their daily lesson planning. These factors varied from student ability, classroom management, material availability and time considerations.

Based on the responses to the survey, the two largest perceived barriers to IBL were time and assessments. Time constraints are often a concern of teachers using IBL due to the hands-on, student led nature of IBL, and this is often cited as a major concern among science teachers, in regard to IBL use (Au, 2007; Englen et al., 2013; Dorier & Garcia, 2013; Fitzgerald et al., 2017). Curriculum restriction, and the assessments associated with school curriculums is another well documented barrier to IBL (Anderson, 2011; Au, 2007; Scogin et al., 2017; Taylor et al., 2008).

While slightly over one-half of teachers did report concerns over student's ability to successfully perform IBL, student behavior or classroom management was not reported as a serious limitation by participants of this study. This varies from other studies that reported that a most teachers perceived student ability as a major limitation to IBL (Roehig & Luft, 2004; Wallace & Kang, 2004). In contrast, over one-third of teachers reported a lack of confidence in their own ability to teach using IBL, even though over three-quarters of the teacher reported an awareness of the principals of IBL, and while not specific to IBL previous research does point out that teachers teach in a manner in which they feel most confident (Marshall & Drummond, 2006; Nespor, 1987).

Research Question 4

Research question four was answered using a Pearson's Product Moment Correlation (Pearson's r). Results of the Pearson's product moment correlation indicated there was a statistically significant positive relationship between teacher intent to use IBL and their use of IBL in their daily lessons. Based on previous research, teachers have been shown to teach what they feel is best for their students regardless of its effectiveness in student learning (Anderson, 2011; Wallace & Kang, 2004). These studies did not attempt to correlate teacher intent as a factor of how they teach. The PRIMAS survey originally was used to compare teacher perception to use and did not consider teacher intent (Englen et al., 2013). Based on the review of the literature, this is the first time a correlation between teacher intent and use of IBL has been reported.

Research Question 5

Research question five How well do science teachers understand the concept of IBL?, was addressed by using a qualitative inductive coding process. In an attempt to better understand teacher responses to the PRIMAS survey, an open-ended question was added; "In your own words, please define Inquiry-Based Learning." Eighty-one of the responding teachers provided some definition of IBL in the free response part of the survey.

Responses to research question five were organized into subthemes related to how well teachers defined IBL in their own words. Teacher familiarity with inquiry is another issue impeding its implementation in the classroom (Anderson, 2011; Capps & Crawford, 2012; Oner, & Capraro, 2016). Based on the level of understanding the responses were assigned to four subthemes including: (a) teachers who do not understand IBL, (b) teachers act as facilitators during IBL, (c) students are in control of their learning, and (d) students are given leading questions.

Teachers who cannot define IBL. Based on the responses given in the survey, only approximately ten percent of teachers do not understand, or cannot adequately define IBL. The other ninety percent had at least a basic grasp of the principles of IBL instruction. This is inconsistent with what has been found in previous research. Capps and Crawford (2012) found "instruction related to understandings about inquiry, either implicit or explicit, was not observed or described in any of these teachers' classrooms (p. 520)." While we did not directly observe the teachers participating in this study, their ability to define the essential elements of IBL demonstrate at least implicit knowledge.

Another common factor impacting understanding of IBL has been that teachers often struggle to define true inquiry-based learning and often confuse it with other hands-on approaches or active learning styles (Fitzgerald et al., 2017). However, based on the responses given in this subtheme, where only a small percent of teachers were unaware of the components of IBL, we can conclude that a broader understanding of IBL has arisen. The reason for the increased awareness of IBL and its concepts in unknown as teachers' backgrounds and content knowledge were not part of the study.

For teachers who provided definitions of IBL, we can distinguish three subsets: (a) teachers act as facilitators, (b) students are in control of learning, and (c) students are given questions. In each of these categories we see that the teacher has a basic understanding of the concept of IBL, at least through the aspect that they use to define it. This further demonstrates that teachers who participated in the study have a greater understanding of the concepts of IBL than reported in previous studies.

Teachers who act as facilitators. In this category, teachers see themselves as guides to student learning. Here we see a common principal of IBL, that students conduct research to increase their understanding while the teacher provides support without direct instruction (Bell, 2010; Capps & Crawford, 2012; Feyioglu, 2019; Walker, 2015).

Teachers who see themselves as facilitators allow for more freedom in allowing students control regarding problem solving during lessons. In this style of instruction, students gain knowledge without being forced into routine learning practices like note taking or worksheets. Facilitation is the first step in the process of implementation of IBL. Through facilitation students learn to work independent of teacher control.

Teachers who see themselves as a facilitator of learning are open to IBL and with support can increase the use of IBL in the classroom. Teacher beliefs that are centered around the facilitation of student learning would be more likely to implement inquiry-based learning; while teachers whose beliefs are centered in their personal responsibility for student learning would focus on more teacher centered practices (Marshall & Drummond, 2006). For IBL to become common there is a need for teachers to believe in themselves as facilitators of learning and not as providers of education.

Students are in control of learning. Another subtheme is that of students being in control of their own learning. This method of learning varies from the “traditional” way of direct instruction which typically includes memorization and formulaic laboratory work (Cobern et al., 2010). In a traditional teacher centric classroom, the teacher dominates the discussions and the student acts only to participate through guessing the answer to questions or performing repetitive tasks like workbook activities. Many of the problems that STEM students face are a result of this traditional methodology of teacher focused instruction (Anderson, 2011; Bicer et al., 2017; Bicer et al., 2015; Collier et al., 2018; Filippi & Agarwal, 2017).

The definitions provided by teachers who view IBL as student-controlled learning are similar to the definitions that include teacher facilitation but take it a step further. Here the student decides what part of the topic is studied and how to best learn based on the expectations set at the beginning of the lesson. Teachers who report that IBL is centered around student control also acknowledge that the teacher is there as a guide and does not actively instruct the student on how to proceed unless the student starts to move away from the topic in question. This definition is within the traditional concept of IBL which has been described in the following way. Inquiry-Based Learning supports the scientific method of discovery because students ask a question, plan and design experiments, collect data and utilize this data to develop a unique answer to their problem (Bell, 2010; Capps & Crawford, 2012; Feyioglu, 2019; Walker, 2015).

Students are given questions. Another way in which IBL was defined is as the use of questions to guide student learning. The process of IBL is founded on many of the same principals as authentic scientific inquiry allowing the student to uncover observable regularities (Colburn, 2000; Dudu & Vhurumuku, 2012). While this may not be true scientific inquiry, many of the steps are the same. Students use questions to form hypotheses, just like in scientific experiments. The students also conduct research to find the answer to the driving question (Dudu & Vhurumuku, 2012; Marshall, 2015).

Nearly half of the teachers that provided definitions of IBL included statements regarding students receiving questions to answer as part of an IBL lesson. A major component of IBL is the "driving question" that teachers provide the students. In this way teachers set a standard for what the student is to focus on. This allows the student to work independently but within a range of topics as provided by the driving question. Teachers who define IBL as students given questions are on the right track for IBL especially those teachers who conclude that student use independent research to answer the questions with limited teacher instruction.

Research Question 6

Research question six, How do science teacher perceptions impact their daily use of IBL?, was addressed by using a qualitative inductive coding process. In an attempt to capture a more in-depth understanding of the influence that teacher perceptions of IBL have on their use of IBL in their daily lessons, six teachers total (three who stated they use IBL routinely and three who stated they seldom use IBL in their daily lessons) were interviewed regarding their current teaching practice, their perceptions of IBL, and their perceived limitations to IBL implementation.

Responses to research question six were organized into subthemes related to how teachers conducted their daily lessons, their perceptions of IBL and their perceived limitations to implementing IBL in their own daily lessons. Teacher responses to how they conducted their daily lessons varied between the high IBL group and the low IBL group. However, teacher responses to the questions regarding the benefits and limitations to implementation were consistent between the two groups of teachers. The responses from the interviews were divided into four subthemes: (a) teacher driven instruction, (b) inquiry driven instruction, (c) perceptions of IBL, and (d) limitations to inquiry were identified based on teacher responses.

Teacher driven instruction. Teachers in the Low- IBL group shared similar experiences in teaching their students by direct instruction. These teachers discussed using notes and assignments based on repetition in order to prepare students for district prepared Curriculum Based Assessments (CBAs). Teachers were motivated to use direct instruction in order to prepare their students for tests, keep them on topic, and complete the curriculum in the timeframe set by the state/school guidelines.

All of these factors are consistent with previous research into direct instruction and teacher motivation for lack of IBL in daily lessons (Anderson, 2011; Au, 2007; Englen et al., 2013; Roehrig & Luft, 2004; Schoenfeld & Kilpatrick, 2013; Tofel-Grehl & Callahan, 2017; Wallace & Kang, 2004). Standardized tests and the scope and sequence of the state curriculum have been identified as the primary reason that teacher prefer direct instruction in STEM subjects (Anderson, 2011; Au, 2007; Donnelly & Sadler, 2008; Scogin et al., 2017; Taylor et al., 2008). Prior research also suggests that this is unnecessary. By implementing IBL, students grow and develop their own understanding of science in in a manner that is best suited to their individual style while developing critical thinking skills that will allow them to be successful post high school graduation (Englen et al., 2013). Inquiry has also been shown to be effective in increasing students' overall achievement in science (Bicer et al., 2015; Filippi & Agarwal, 2017; Freeman et al., 2014; Freeman et al., 2007). Student-centered instructional strategies, like IBL, have been shown to be as effective at preparing students for standardized tests as traditional teacher-centered instruction (Freeman et al., 2014; Scogin et al., 2017).

Student centered instruction: Teachers in the High-Use IBL group reported more open classroom instructional styles. Teachers reported using different levels of IBL at different frequencies. But consistent within their description of their classrooms was the idea that learning was student centered and that exploration was the major method of learning. Students were given the responsibility of conducting their own investigations in response to questions asked by the teacher. Each student used their own skillset to determine the methods involved in coming developing the answers.

Teachers in this group felt that they were facilitators of learning and that student performance was based on the student's own desires, not on forced repetition. Facilitation allowed the teachers to observe the students in the process of learning without forcing a particular style or set of instructions on the students during the course of the lesson. The types of responses recorded from the High-Use group of teachers are, in general, consistent with the findings of other researchers when they interviewed teachers who use IBL on a routine basis (Englen et al., 2013; Fitzgerald et al., 2017).

Inquiry-based learning isn't the only method for teaching STEM subjects, but it has the benefit of exposing students to the type of methods utilized by practicing scientists. This helps students to develop a deeper understanding of science and more importantly leads to the development of critical thinking skills (Capps & Crawford, 2012; Colburn, 2000; Walker, 2015). Overall, forty-one percent of teachers who participated in this study self-report using IBL in some for as part of their daily lesson plans. Previous research has shown that the majority of teachers do not use IBL as part of their daily teaching practice (Freeman et al., 2014; Harrison, 2015; Marshall, 2010; Roehrig & Luft, 2004; Walker, 2015). While these studies do not report percentages for direct comparison, the results of this study imply a higher rate of IBL and student-centered learning that previously reported. These results merit further investigation and future research may shed light on the actual levels of IBL instruction when compared to the reported levels addressed by this study.

Perceptions of IBL. Teachers from both the high and low use groups were consistent in their agreement that IBL has a positive impact on student learning. Teachers stated that the benefits to students were in the ownership of the material and the improvements in the learning process as students were more willing to participate. By allowing students to work in a manner that best suits them, the student gains knowledge and the confidence to work outside the structures of a ridged classroom environment (Bicer et al., 2015; Englen et al., 2013; Filippi, & Agarwal, 2017; Freeman et al., 2014; Freeman et al., 2007). Teachers who participated in the interview process also discussed the ability to transfer critical thinking skills, which they described as essential for students in and out of the classroom. Within the process of learning through IBL, students utilize independent research techniques that build critical thinking skills (Castro & Morales, 2017; Englen et al., 2013; Filippi, & Agarwal, 2017). These findings are consistent with those of previous research that describe IBL as having multiple benefits to students (Bicer et al., 2015; Capps & Crawford, 2012; Colburn, 2000; Englen et al., 2013; Filippi & Agarwal, 2017; Freeman et al., 2014; Freeman et al., 2007; Walker, 2015).

The process of IBL also was viewed, by the participants of this study, as having benefits to the teachers. Teachers remarked that classroom management was potentially easier since all students would be engaged in their own learning processes. In general studies have found that classroom management is of minimal concern to the process of IBL (Englen et al., 2013). But this study did not discuss teacher beliefs in terms of how classroom management was affected. Teachers that addressed classroom management in this study were able to point out that student ownership of learning meant that students were engaged and actively participating at all times. This is something that they had not seen in their classrooms prior to implementing IBL strategies. In being able to get students to buy into the concept of IBL teachers were able to reduce the time spent trying to get students to participate. Also addressed by teachers in this study was that in allowing students to conduct their own learning, the pressure to get students to perform were thought to be lessened. Students no longer needed to be reminded of assignment dates and assessments that were developed to address IBL principals allowed students to demonstrate mastery of the topic and not just memorization of the terminology.

Factors limiting IBL implementation. Overall, teachers had a positive perception of IBL and consistently acknowledged that IBL was beneficial to students. However, both groups also felt that there were various barriers to the implementation of IBL. These responses were similar among the two groups, however the high use group acknowledged that these limitations were things that they were able to overcome or were expressed by other teachers they work with.

The most common limitation mentioned by teachers who participated in the interviews was time. Time constraints were addressed in two ways. Primarily, the amount of time that an IBL takes if students are allowed to explore a topic in-depth. This was especially a concern for the Low-Use group, as they described issues with students' performance and inability to complete the tasks given in the traditional classroom setting. Teachers expressed concern that they could not get students to complete the assignments in the time allotted by the curriculum planners in their districts. The secondary issue with time expressed was that of class periods and how shot they were.

Teachers were concerned that students could not accomplish much during the school day and the true IBL would need to continue out of class. This is consistent with previous findings of studies focus on both proponents and detractors of IBL (Donnelly & Sadler, 2008; Dorier & Garcia, 2013; Englen et al., 2013; Fitzgerald et al., 2017; Taylor et al., 2008). However, the High-Use group described the ability of the students to overcome all of the timing challenges. They discussed the fact that student engagement and participation allowed for more in-depth study and more completed assignment, which easily made up for the extra time commitments. These teachers also agree that student performance was enhanced by IBL and that the amount of time allotted in the curriculum was a problem regardless of the methodology used to teach. In this way they disagree with the previous studies in which the time constraint prevented any attempts at IBL.

Another common area of concern, especially among the low use group was student ability. Teachers were concerned that their students could not handle the rigor of IBL. These teachers emphasized that they taught basic level classes and that the non-advanced students were not prepared for basic class instruction, therefore they could not conceive of a way to incorporate IBL or any learning style in which students controlled their own problem-solving techniques. They were also concerned that their students did not complete basic assignments and that giving them control of their assignments would lead to fewer completions, not more. This issue is also common in the literature. Teachers often teach to how they best think their students will learn, and low-achievers often get basic teaching strategies due to perceptions of their motivation and abilities (Anderson, 2011; Roehig & Luft, 2004; Tofel-Grehl & Callahan, 2017; Wallace & Kang, 2004).

Research has demonstrated that this is not necessarily an area that should limit IBL and both high and low achieving students benefit from it (Chen et al., 2020). The High-Use teachers from this study again proved this to be of little concern. They reported using IBL regardless of student ability. However, the did concede that they used a more structured approach to IBL, with slightly less freedom of student creativity in problem solving. This strategy demonstrates the ability of these teachers to problem solve in a way that encourages students' active learning. This is the underlying concept of IBL, to promote student learning and incorporate a problem-solving mindset that will go beyond the classroom.

Implications

As a result of this study's examination of teacher's perceptions, use, and perceived limitations to IBL, implications for teachers, campus administrators, and policy makers emerged. For teachers, the research provides a deeper insight into how teacher perceptions impact their teaching style and provides some direction to overcome perceived barriers to IBL. For administrators, the current research study provided teachers with a voice to discuss how policy and planning can negatively impact the implementation of IBL. For policy makers, such as state and federal education agencies and governmental officials, the research provided information regarding the impact of agency mandated curriculum standards and testing on the implementation of IBL.

Implications for Teachers

Teachers are tasked with the education of students and they are the ones that must decide the methodology that is used in the classrooms in order to best meet the demands on their students. Teacher perceptions of the pressures placed on them and the method of instruction are causally related as shown in multiple studies (Anderson, 2011; Au, 2007; Englen et al., 2013, Roehrig & Luft, 2004; Schoenfeld & Kilpatrick, 2013; Tofel-Grehl & Callahan, 2017; Wallace & Kang, 2004). Too often teachers rely on worksheets, notes, and "cookie-cutter" labs to get students to sit and work through the curriculum in the most time efficient manner (Cobern et al., 2010; Marshall, 2010). This teaching style is the result of pressure from the curriculum, the administration, and peers to make life as simple as possible on teachers and students (Anderson, 2011; Au, 2007; Harrison, 2015; Marshall & Drummond, 2006; Robertson & Elliott, 2018; Wallace & Kang, 2004; Zohar & Agmon, 2018). While this methodology is relatively easy and requires minimal effort in planning, as most worksheets and notes can be found online), it is ineffective in producing graduates that can adapt and grow in the less structured environments of college and career pathways. Approximately forty-one percent of teachers in this study reported using some form of IBL. However, the level of inquiry and the actual type of lessons are unknown. Previous studies have shown that teachers often confuse IBL with other hands-on learning styles (Capps & Crawford, 2012). As a result, we cannot verify the claims made by these teachers. Even if these number are accurate, our interviews demonstrate that teachers at the high use end of the spectrum still use Structured or Guided Inquiry most of the time. Therefore, as this study demonstrates, there is a critical need for teachers to increase the amount and level of IBL in the classroom. These higher-level teaching strategies have been shown to impart students with critical thinking skills along with the content knowledge required by the curriculum (Bicer et al, 2015; Fillippi & Agarwa, 2017; Freeman et al., 2014).

Humans are naturally inquisitive, as any parent can tell you. We begin our life questioning the way things work. It is the mundane nature of most learning that eliminates student desire and motivation to learn. By applying student-driven learning styles, like IBL, teachers can motivate and prepare our students for the world outside secondary education (Capps et al., 2000; Walker, 2015). The findings of this study support the idea that teachers can teach IBL and enhance student learning, while still meeting demands placed on them by administrators and policy makers. As demonstrated by participants in this study, teachers can overcome the perceived barriers to IBL and include IBL in daily lessons. Teachers interviewed in the study have also used IBL to create classrooms that promote student learning in a way that has real life application through the teaching of critical thinking and problem-solving skills.

This study also showed the correlation between teacher intent and application when it comes to IBL. Teacher perceptions are tied to teaching in many ways. Perceptions of student ability, of the expectations placed on them by the district/state curriculums, and by peers influence how teachers teach (Anderson, 2011; Au, 2007; Englen et al., 2013, Roehrig & Luft, 2004; Schoenfeld & Kilpatrick, 2013; Tofel-Grehl and Callahan, 2017; Wallace & Kang, 2004). Since teacher perception is correlated to implementation, teachers should work to improve their understanding of IBL and the ways to overcome the perceived barriers in order to support their student's future growth. If there is greater understanding of the process, teacher intent can be improved upon. With increased intent, comes increased use. It is ultimately, the responsibility of teachers to know their students' needs and personalities and to provide these students with the means to be successful and grow as critical thinkers and contributors to society.

Implications for Administrators

The correlation between teachers' intent and use of IBL is also important for administrators to note. Administration is responsible for determining the types and number of trainings teachers can attend, the amount of flexibility a teacher is allowed when implementing the curriculum, and the methodology used in assessing student learning. In order to improve student understanding, teacher knowledge must also be addressed. Therefore, campus administrators implement professional development opportunities for staff (teachers and paraprofessionals) that are specific to the needs of their teachers based on the subject taught and the types of students being addressed. Teachers often receive little, to no, support or training for the application of best practices (Czerniak & Brooks, 2017). This leaves teachers with little opportunity to grow and adapt more effective teaching strategies, like IBL. In order to impact students, teachers need the support and training to bring inquiry into the classroom. Research also suggests that continuous support in learning, instead of single staff development delivery, is required to allow teachers to incorporate these advanced teaching methods (Czerniak & Brooks, 2017). Overall, changes to the way teacher development opportunities are scheduled and assigned are required to incorporate teaching practices like IBL.

Administrators also need to provide encouragement to teachers to try new techniques without the fear of consequences if their students do not meet expectations immediately. State and district mandated curricula often emphasize breadth over the depth of a subject (Donelly & Sadler, 2008; Taylor et al., 2008). This puts pressures on administrators to encourage time restrictions on assignments and limits teacher freedom. Administrators need to be aware that the traditional teaching methods that make it easy to fit a lesson into a time slot are not effective at preparing students for post-secondary life

(Anderson, 2011; Bicer et al, 2017; Bicer et al, 2015; Collier et al, 2018; Fillippi & Agarwal, 2017).

Another implication that applies to the administration is the use of teacher evaluation systems. As a routine part of the evaluation process administrators walk through classrooms and evaluate a teacher based on what they observe in the classroom. However, there is little difference to the untrained eye between a student actively engaged in an inquiry style activity that has the student moving around the room, and a student who is just up and being disruptive. IBL is active learning and students often are working on different things at different times, some independently and some in groups. Administrators need to be able to recognize this is teachers are to impliment these activities in their lessons more often.

The pressures placed on teachers to meet certain levels of student passing percentages on standardized exams has also impacted teaching strategy (Anderson, 2011; Au, 2007; Freeman et al., 2014; Scogin et al. 2017). State mandated and administered exams that tend to focus on factual regurgitation during a multiple-choice exam are out of district and school control. However, many districts also administer curriculum-based assessments (CBAs) that are planned and developed by the district itself. Administrators, in these districts, should work to develop CBAs that focus on student understanding and reasoning skills. In this way the benefits of IBL can be seen in students as they go through the learning curve associated with all new strategies.

Implications for Policymakers

Many officials who make education policy have no K-12 school experience with the exception for having been a student. That lack of understanding of what students need can be a problem for teachers, students, and their families. Various policymakers have good intentions, but they often lack a practical understanding of the realities in classrooms. This is evident in the fact that curriculum reform continues to encourage the use of IBL (Committee on Conceptual Frameworks, 2012; Committee on STEM Education, 2018; NRC, 1996, NGSS, 2013, TEKS, 2017)., while its actual use is still limited by many factors (Anderson, 2011; Au, 2007; Englen et al., 2013, Roehrig & Luft, 2004; Schoenfeld & Kilpatrick, 2013; Tofel-Grehl and Callahan, 2017; Wallace & Kang, 2004). Policymakers, however, are in a unique position. They possess the ability to completely overhaul the educational system itself. This power means that policymakers have a unique opportunity to impact student learning in multiple ways. These impacts range from changing the expectations placed on schools and districts based solely on performance-based testing changing, changing the way teachers are trained, and changing the way students are assessed.

When considering setting district and school performance standards it is important to consider the multitude of factors that each district faces in educating their unique group of students. It is a difficult prospect to look at the diversity of the nation, a state, or even a single city and decide that changes must be made to impact each region or area independently of the others. However, in assessing school and districts based on the passing rate of a single set of standardized exams we group all our students from all of their backgrounds into a single "type." Standardized testing has proven to be a difficult method of assessing student learning. And so, new strategies need to be developed to assess the performance of a district. Graduation rates, college, and career placement numbers, combined with overall student performance on assessments like the ACT, SAT, and ASVAB tests can be combined to give a more in depth look at the performance of the district in serving its students.

When considering teacher training it is important to view teaching as an ever-evolving process, students change, technology advances, and techniques are developed.

However, at this time there is no guideline for continued education within the field of education. Teachers in Texas, are required to obtain 150 hours of continued professional education (CPE) in order to renew a teaching certificate (TEA.gov, 2020). Teachers are free to obtain these hours within any pre-approved CPE subject, regardless of its application to that teachers grade level or subject taught. This encourages mass CPE service courses that focus on providing teachers with information of policy changes, classroom management ideas, and team-building strategy. None of these subjects improve student learning, student motivation, or student critical-thinking skills. Changes to CPE requirements, that ensure teachers are receiving content-specific and student-centered CPE hours will improve classroom practice and graduate success.

When considering student assessment, it is important to understand the difference between memorization and understanding. Current state-based assessments are content focused and generally formatted into multiple-choice style tests. Bloom's Taxonomy, the basis for many educational principals, sets knowledge, or the ability to recall information, at the lowest level of understanding (bloomstaxonomy.net, 2021). As such, these state-based assessments do not truly assess knowledge and have an extremely limited ability to determine critical thinking ability (Anderson, 2011, Bicer et al, 2015; Young, et al, 2018). These tests and the pressure to get students to pass often lead teachers to ignore best-practice and focus on memorization only (Anderson, 2011; Au, 2007; Katzmann, 2007; Moon et al., 2003). In order to reach the students in a meaningful way, we must prepare lessons that encourage students to develop life skills like critical thinking. Therefore, state-based assessments must be changed to incorporate the idea of performance-based testing. Students taking vocabulary tests are taught vocabulary only, however, students taking practical exams are shown how to conduct the processes being tested. We cannot expect a student with a list of definitions and no practical experience to drive a car, and we cannot expect students forced to take content level, vocabulary-focused exams to understand how to think and act outside of the classroom. Changes to testing are a direct line to changes in teaching strategy. Overall, for policymakers, it will be listening to what teachers, themselves have to say, that will allow them to better be able to make decisions that are relevant to the experiences and needs of both teachers and students.

Recommendations for Future Research

Findings from this study involved obtaining feedback (quantitative and qualitative) from 6-12th grade science teaches. Although the findings provided data and information about teachers' perceptions, recommendations for future research will help expand the knowledge on this topic. This research study elicited many topics of consideration for improving teacher implementation of IBL. The following recommendations are based on data and findings from this study.

This study took place across Region 4 in southeast Texas. This region serves approximately 1.2 million students enrolled across 48 districts and 39 charter organizations. Data collection from a sample of the ESC or across multiple ESCs may produce different results. However, based on the size and diversity of the ESC, the results are applicable across many different districts withing the state of Texas. One recommendation for future research would be to include direct observation of teacher interactions in the classroom. As demonstrated by this and other studies, IBL is often misunderstood or confused with other hands-on learning styles, and direct observations will allow researchers to determine if teachers' self-reported IBL, as determined through survey or interview responses, meet the standards of the traditional definition of IBL. The impact of IBL on bilingual students or ELL students is another area to be addressed. These students often struggle in vocabulary-style learning and IBL may be beneficial to students with a limited grasp of the English language. Another area of future research could be to incorporate curriculum development strategies regarding the principals and application of IBL in order to improve teacher awareness of IBL and increase teacher intent to implement IBL. Finally, data should be collected from administrators to see how their perception of the state and local testing affects how they control the practices of teachers within their districts.

Conclusion

The relationship between teacher perceptions and IBL has been well researched. Researchers suggest that high perceptions do not always lead to high implementation due to perceived barriers (Anderson, 2011; Au, 2007; Harrison, 2015; Marshall & Drummond, 2006; Robertson & Elliott, 2018; Wallace & Kang, 2004; Zohar & Agmon, 2018). Given that many students are not prepared to meet the need of post-secondary life (Freeman et al., 2014; Jansen et al., 2013; Mah, 2016; OECD, 2018; Woolley et al., 2018; Zeineddin & Abd-El-Khalick, 2010). it is important that we address student learning and understanding in the classroom. The ability to think critically, not just memorize facts is imperative for lifelong success. IBL has been shown to impart both knowledge of the curriculum and life skills like critical thinking (Capps & Crawford, 2012; Colburn, 2000; Walker, 2015). By demonstrating a correlation between teacher intent and actual use of IBL, along with revelations by teachers regarding their perceptions of student performance and classroom management, the findings of this study could provide significant contributions not only to teachers and administrators, but to the overall discussion on the relationship between teacher intent and use of IBL along with the internal and external factors the limit teacher implementation of IBL.

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APPENDIX A:

SURVEY COVER LETTER

Greetings!

You are being solicited to complete the *Perceptions of Inquiry-Based Learning Survey*. The purpose of this survey is to examine the perceptions of secondary science teachers in terms of intended use, actual use, and barriers to inquiry-based learning.

Please try to answer all the questions. Filling out the survey is entirely voluntary but answering each response will make the survey most useful. This survey will take approximately 5-10 minutes to complete, and all responses will be kept completely confidential. No obvious undue risks will be endured, and you may stop your participation at any time, in addition you will not benefit directly from your participation.

https://uhcl.co1.qualtrics.com/jfe/form/SV_20q8iYHbKFNuH5j

Your cooperation is greatly appreciated and your willingness to participate in this study is implied if you proceed with completing the survey. Your completion of the *Perceptions of Inquiry-Based Learning Survey* is not only greatly appreciated, but invaluable. If you have any further questions, please feel free to contact me at any time.

Sincerely,

Stephen Gruber
Lecturer-Biology
University of Houston-Clear Lake

APPENDIX B:

TEACHER PERCEPTION TO INQUIRY

Inquiry Survey

Start of Block: Inquiry-Based Learning

Q1 *Are you Certified to teach grades 6-12 Science?*

○ Yes (13)

○ No (14)

Skip To: End of Survey If Are you Certified to teach grades 6-12 Science? = No

Page Break

Q2 A. Regarding my intent to use IBL

	Strongly Disagree (1)	Disagree (2)	Agree (3)	Strongly Agree (4)
I would like to implement more IBL practices in my lessons (1)	○	○	○	○
IBL is well suited to overcome problems with student motivation. (2)	○	○	○	○
I regularly do projects with my students using IBL (4)	○	○	○	○
I would like to do more IBL to enrich my teaching practice. (5)	○	○	○	○
IBL is part of my daily teaching. (6)	○	○	○	○
IBL is a well suited approach to students' learning (7)	○	○	○	○
I want to be part of a more coordinated and effective approach to IBL. (8)	○	○	○	○

Q3 B. In my classroom, the students...	Never or Hardly Ever (1)	In Some Lessons (2)	In Most Lessons (3)	In almost all lessons (4)
...are given opportunities to explain their ideas. (1)	○	○	○	○
...spend time doing practical experiments/investigations. (2)	○	○	○	○
...have the possibility to try their own ideas. (3)	○	○	○	○
...do experiments/investigations by following my instructions. (4)	○	○	○	○
...repeatedly practice the same method on many questions. (5)	○	○	○	○
...have discussions about the topic (6)	○	○	○	○
...learn through doing exercises. (7)	○	○	○	○
...draw conclusions from experiments/investigations they have conducted. (8)	○	○	○	○
...design their own experiments/investigations. (10)	○	○	○	○
...have the possibility to decide how things are done during the lesson. (11)	○	○	○	○
...do experiments/investigations to test their own ideas. (13)	○	○	○	○

...are involved in class debate/discussion. (15)	○	○	○	○
...have the chance to choose their own experiments/investigations. (16)	○	○	○	○
...work on problems that are related to real life experiences. (18)	○	○	○	○
...start with easy questions and move onto harder questions. (19)	○	○	○	○
...have influence on what is done in the lesson. (20)	○	○	○	○
...chose which questions to do or which ideas to discuss. (21)	○	○	○	○
...are informed about he aim of the lesson. (22)	○	○	○	○
...do experiments/investigations that can be done/answered using more than one method (24)	○	○	○	○

Q4 C. I have difficulties in implementing IBL, because...	Strongly Disagree (1)	Disagree (2)	Agree (3)	Strongly Agree (4)
...the curriculum does not encourage IBL. (1)	○	○	○	○
...I have a lack of adequate teaching materials. (2)	○	○	○	○
...IBL is not included in the textbooks I use. (3)	○	○	○	○
...I don't know how to assess IBL. (4)	○	○	○	○
...I enjoy the way teaching works right now. (5)	○	○	○	○
...I don't have access to adequate CPD programs involving IBL. (6)	○	○	○	○
...I worry about student's discipline being more disruptive in IBL lessons. (7)	○	○	○	○
...I don't feel confident in IBL. (8)	○	○	○	○
...I am worried about my students getting lost or frustrated in their learning. (9)	○	○	○	○
...I think the students are happy with the way I teach. (10)	○	○	○	○

...I think that group work is difficult to manage. (11)	○	○	○	○
...there is not enough time in the curriculum. (12)	○	○	○	○
...I don't have sufficient resources, such as computers, lab equipment, ... (13)	○	○	○	○
...my students have to take assessments that don't reward IBL. (14)	○	○	○	○
...the school system does not encourage changes. (16)	○	○	○	○

Q5 D. Knowledge and Concerns of IBL use	Strongly Disagree (1)	Disagree (2)	Agree (3)	Strongly Agree (4)
I have spent some time thinking about IBL. (1)	○	○	○	○
I know about the principals of IBL. (3)	○	○	○	○
I know about the immediate requirements of using IBL. (4)	○	○	○	○
I am concerned about criticism of my work when I try to implement IBL. (5)	○	○	○	○
I am concerned about the time and energy required for implementing IBL. (6)	○	○	○	○
I am concerned that I cannot manage all that IBL pedagogies require of me as a teacher. (8)	○	○	○	○
I am concerned about the tension between IBL and effectively preparing students for exams. (9)	○	○	○	○
I am concerned that preparing IBL lessons takes extra time. (10)	○	○	○	○
I am concerned about students' attitudes toward IBL. (11)	○	○	○	○

I am concerned about the effects of IBL teaching on students' performance overall. (12)	○	○	○	○
I am concerned that classroom management of IBL is difficult. (14)	○	○	○	○

Q6 In your own words, please define Inquiry-Based Learning

____

____

____

____

____

Q7 Please identify your gender.

○ Male (1)

○ Female (2)

Q8 What is your race/ethnicity?

- ◯ Hispanic or Latino (1)
- ◯ Caucasian or White (2)
- ◯ Black or African American (3)
- ◯ Asian (4)
- ◯ American Indian or Native Alaskan (5)
- ◯ Native Hawaiian or other Pacific Islander (7)
- ◯ Two or more races (6)
- ◯ Other (8) ____

Q9 Subject Taught (Check all that apply)

- ▢ Aerospace science (5)
- ▢ Anatomy/Physiology (6)
- ▢ Aquatic Science (7)
- ▢ Biology (8)
- ▢ Botany (9)
- ▢ Chemistry (10)
- ▢ Earth Science (11)
- ▢ Environmental science (12)
- ▢ Forensic Science (13)
- ▢ Integrated Physics and Chemistry (IPC) (14)
- ▢ Microbiology (15)
- ▢ Physical science (16)
- ▢ Physics (17)
- ▢ Zoology (18)
- ▢ 6th Grade Science (21)
- ▢ Click to write Choice 17 (22)

☐ Click to write Choice 18 (23)

☐ Other (Please Specify) (19) ____

Q10 Total years teaching science.

____

Q11 Years teaching in current teaching position.

____

Page Break

Q12 If you would be willing to participate in a brief (30 minute) zoom or phone interview to further assist in the collection of this research data, please include your full name, e-mail address, and phone number below. All information received here will be kept confidential and destroyed following the completion of this study. By providing information below you are agreeing to have the researcher contact you regarding the interview process.

- ◯ Name (4) ____
- ◯ Phone Number (5) ____
- ◯ Email Address (6) ____

End of Block: Inquiry-Based Learning

APPENDIX C:

INFORMED CONCENT LETTER

Informed Consent to Participate in Research

You are being asked to participate in the research project described below. Your participation in this study is entirely voluntary and you may refuse to participate, or you may decide to stop your participation at any time. Should you refuse to participate in the study or should you withdraw your consent and stop participation in the study, your decision will involve no penalty or loss of benefits to which you may be otherwise entitled. You are being asked to read the information below carefully, and ask questions about anything you don't understand before deciding whether or not to participate.

Title: Inquiry-Based Learning: Perceptions, Use, and Barriers for 6-12 Science Teachers

Principal Investigator(s):
Student Investigator(s): Stephen Gruber, MS
Faculty Sponsor: Michelle Peters, EdD

PURPOSE OF THE STUDY

The purpose of this research is to The purpose of this study is to examine teacher's perceptions on the intent to use, the use, and the barriers to implementing inquiry-based learning.

PROCEDURES

This research study will utilize a mixed methods (Quan-->qual) design regarding the perceptions inquiry-based learning in grades 6-12 science classrooms. The design will consist of a quantitative and a qualitative phase. The advantage of implementing this design is that it allows for a more thorough and in-depth exploration of the quantitative results by following up with a qualitative phase. A purposeful sample of 6-12th grade science teachers, teaching in Region 4 in southeast Texas will be solicited to complete the Promoting Inquiry in Math and Science (PRIMAS) Survey and participate in semi-structured interviews. For the quantitative phase, survey data will be analyzed frequencies and percentages, Qualitative data, based on responses from the interviews, will be analyzed using an inductive thematic coding process.

EXPECTED DURATION

The total anticipated time commitment will be approximately 30 minutes

RISKS OF PARTICIPATION

There are no anticipated risks associated with participation in this project.

BENEFITS TO THE SUBJECT

There is no direct benefit received from your participation in this study, but your participation will help the investigator(s) better understand how teachers' intent and perception of barriers influence tier use of IBL in daily lessons.

CONFIDENTIALITY OF RECORDS

Every effort will be made to maintain the confidentiality of your study records. The data collected from the study will be used for educational and publication purposes, however, you will not be identified by name. For federal audit purposes, the participant's documentation for this research project will be maintained and safeguarded by the Principal Investigator for a minimum of three years after completion of the study. After that time, the participant's documentation may be destroyed.

FINANCIAL COMPENSATION

There is no financial compensation to be offered for participation in the study.

INVESTIGATOR'S RIGHT TO WITHDRAW PARTICIPANT

The investigator has the right to withdraw you from this study at any time.

CONTACT INFORMATION FOR QUESTIONS OR PROBLEMS

The investigator has offered to answer all your questions. If you have additional questions during the course of this study about the research or any related problem, you may contact the Student Researcher, Stephen gruber, MS, at 281-283-3779 or by email at gruber@uhcl.edu.

If you have additional questions during the course of this study about the research or any related problem, you may contact the Student Researcher, Stephen Gruber, at phone number 281-283-3779 or by email at gruber@uhcl.edu. The Faculty Sponsor Michelle Peters, Ph.D., may be contacted at phone number 202-321-3752 or by email at petersm@uhcl.edu.

SIGNATURES**:**

Your signature below acknowledges your voluntary participation in this research project. Such participation does not release the investigator(s), institution(s), sponsor(s) or granting agency(ies) from their professional and ethical responsibility to you. By signing the form, you are not waiving any of your legal rights.

The purpose of this study, procedures to be followed, and explanation of risks or benefits have been explained to you. You have been allowed to ask questions and your questions have been answered to your satisfaction. You have been told who to contact if you have additional questions. You have read this consent form and voluntarily agree to participate as a subject in this study. You are free to withdraw your consent at any time by contacting the Principal Investigator or Student Researcher/Faculty Sponsor. You will be given a copy of the consent form you have signed.

Subject's printed name: ______________________________

Signature of Subject: ______________________________

Date: ______________________________

Using language that is understandable and appropriate, I have discussed this project and the items listed above with the subject.

Printed name and title ______________________________

Signature of Person Obtaining Consent: ______________________________

Date: ______________________________

THE UNIVERSITY OF HOUSTON-CLEAR LAKE (UHCL) COMMITTEE FOR PROTECTION OF HUMAN SUBJECTS HAS REVIEWED AND APPROVED THIS PROJECT. ANY QUESTIONS REGARDING YOUR RIGHTS AS A RESEARCH SUBJECT MAY BE ADDRESSED TO THE UHCL COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS (281-283-3015). ALL RESEARCH PROJECTS THAT ARE CARRIED OUT BY INVESTIGATORS AT UHCL ARE GOVERNED BY REQUIREMENTS OF THE UNIVERSITY AND THE FEDERAL GOVERNMENT. (FEDERALWIDE ASSURANCE # FWA00004068)

APPENDIX D:

INTERVIEW QUESTIONS

Teacher Interview Guide

1. How would you best describe the style of teaching that occurs in your classroom?

2. How often do students have the opportunity for independent research each year?

3. In the survey you provided a definition of IBL, based on that, *How often would you say that you implement IBL in a typical week*?

   I'm going to ask you some thoughts on IBL...

4. Are there any benefits to IBL? If so, what?

5. Are there any negatives to IBL? If so, what?

6. **The literature gives a set definition of IBL. Let's look at the three levels of inquiry-based learning based on the three levels of Inquiry definition:**
   a. Structured Inquiry: Students are given a problem to solve, a method for solving it, and the necessary materials.
      i. How often do you use this level of IBL in your classroom per week?
   b. Guided Inquiry: Students develop their own methods to solve the problem.
      i. How often do you use this level of IBL in your classroom per week?
   c. Open Inquiry: Students formulate the problem and the method of solving it.
      i. How often do you use this level of IBL in your classroom per week?

7. Are there any limitations to implementing IBL in your classroom? If so, what?
(If he/she mentions some) Of those what is the single biggest barrier?