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Impact of Inquiry Based Learning on Students' Motivation, Engagement and Attitude in Science

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Impact of Inquiry Based Learning on Students' Motivation, Engagement and Attitude in Science

By

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ABSTRACT

This mixed-methods survey and open response design study explored the impact that Inquiry Based Learning (IBL) had on students' attitudes towards science. Students completed the Scientific Attitude Inventory II (SAI II) both at the beginning of the study and after the study. Furthermore, students were asked to respond to open-ended journal questions. The participants included 49 grade 7 students (22 males and 27 females) in Southwestern Ontario who responded to both survey entries and journal response. The teacher implemented an IBL teaching style in science class. The quantitative findings showed a significant trend where students did not agree with statements regarding the importance of society understanding and learning about current scientific efforts. Other quantitative survey findings that were approaching statistical significance involved students being less likely to believe that science had all the answers and that students were less likely to believe that science's main purpose is to develop theories. This may be in part due to the lack of social constructs in the population sampled. Qualitative data gathered through open-ended questions included students finding the hands-on nature of IBL to be very enjoyable; while other students found the lack of structure of the IBL method to be distressing. This brings to attention the need to further understand the inquiry method and how it can benefit learners but also how it may be ineffective with certain learners or in certain circumstances.

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CHAPTER 1

INTRODUCTION

(i) Keywords: inquiry based learning; attitudes towards science; action research; auto-ethnography; social cognitive theory;

Inquiry based teaching involves greater effort to develop, consumes more class time and requires superior autonomy by the students to be deemed a success. If you look in a science textbook you can usually find step-by-step experiments that do support the understanding of concepts, but that do not challenge the student to think or allow them to make greater connections. Challenging students is incredibly important to their development as growth mindset thinkers. Research shows that students who possess a growth mindset or develop one tend to achieve better academically (Aronson, Fried, & Good, 2002; Blackwell, Trzesniewski, and Dweck, 2007; Good, Aronson, and Inzlicht, 2003).

I have been teaching elementary science for 6 years and I have seen the development in my students from creating passive learners that are simply filled with information, to more active learners who seek out information and make meaningful connections. Developing meaningful connections is now a goal of my teaching as I strive to stimulate students' thinking and questioning. Inquiry-based learning (IBL) has improved student engagement in my classroom and has led to many great discussions.

(ii) Statement of Purpose: The purpose of this study is to gain a greater understanding of the impact of IBL on students' motivation, engagement and attitude toward science.

(iii) Research Question(s): How will IBL strategies impact the student's enjoyment or satisfaction in science?

H1: Using IBL in the classroom will improve student enjoyment and satisfaction in science.

How will IBL strategies impact student achievement?

H2: IBL will have an overall positive impact on student achievement either through more positive response or improved academic performance.

Will students prefer the IBL method compared to a more teacher-centered approach?

Students will find the openness and thought-provoking nature of IBL to be more engaging and a better overall learning experience than a more teacher-centered approach.

How will students' attitudes towards science change following the completion of an IBL program?

#1 Will students believe the purpose of science is either testing theories or revealing truths following the IBL process?

#2 Will students believe science's ability to provide all answers to all questions be impacted following the IBL process?

#3 Will students have open minded beliefs and accept that science does not have all answers following the IBL process?

#4 Will students believe that science's purpose is to generate ideas following the IBL process?

#5 Will students believe that science's purpose is to make others aware and that the public benefits from its understanding through the IBL process?

#6 Will students believe working in the field of science would be interesting and rewarding following the IBL process?

CHAPTER 2

REVIEW OF LITERATURE

Inquiry Based Learning (IBL): It's Impact on Students Attitudes in Science

Defining IBL as a teaching strategy can be challenging because it has no universal definition and IBL may have a different pedagogical outlook depending on the subject matter. Gilmer provides a definition for inquiry that reads: "scientific inquiry as the way in which scientists study the natural world and how they propose explanations based on the evidence derived from their work" (1999, p. 11). Additionally, the U. S. National Research Council (2000), describes inquiry in terms of its importance in investigating scientific questions and developing strategies that will support them as scientific learners. Examining both thoughts, the goal of IBL instruction is to challenge students through investigation.

Inquiry Based Learning can be a benefit to both students and teachers alike as it allows them to be more reflective and make interpretations of their learning (Olagoke & Mobolaji, 2014). Kahn and O'Rourke (2005) discuss how IBL allows students to make a variety of different conclusions and expound upon previous learning to form new and greater understandings. The ultimate role of IBL is to stimulate learning in the classroom to better motivate and engage students in their science curriculum (Kahn & O'Rourke, 2005).

According to the Galileo.org inquiry can be described as "…a dynamic process of being open to wonder and puzzlement and coming to know and understand the world" (Retreived August 3, 2017). This ties in directly with the American Association of School Librarians who explain IBL as an active process that can be cyclical in nature and is not a linear process that could lead to a direct and specific result (Jansen, 2011). The content with IBL is the primary area of focus. Students drive the content as they focus on specific areas of interest on any given topic (McLoughlin, 2009).

There is also a matter of who should be involved in developing and enacting IBL. Harvey and Daniels (2009) stress the importance of students having a choice in their pursuit of the inquiry process. It is evident that to engage a student you must provide them with the opportunity to determine their path to investigate the topic and therefore they can determine if the information and knowledge gained is of value. Students should be afforded the right to an equal partnership in their learning experience. Students should be an active part of their learning experience and get out into unchartered areas and ask questions and take risks and then exciting things can happen (Keeling, 2014).

Inquiry skills are not simply skills that become evident every time a student enters science class and is given a problem to solve. Inquiry skills are on display daily as we struggle to find the best way to solve a math problem, research and refine how to write a letter in an effective manner, and learn how to develop relationships. There are times when students will specifically engage in inquiry skills when research is required to further student learning (Feldman et al., 2012). These opportunities allow the student to engage with the task on a deeper level.

Much like providing students with the opportunity to engage in a topic through inquiry research, students can now have their own option of the active search for knowledge through IBL without the direct approach of a teacher-centered lesson (Jansen, 2011). The IBL process occurs when there is a problem that arises, or the learner has a question about a specific issue that they have encountered. Often this can occur when the learner encounters a disconnect between a new topic and their previous learning. The research process lends itself perfectly to the use of the IBL approach as it allows the researcher to ask questions and seek answers that may not only answer their original question but also foster new questions. IBL is very much student driven; students push themselves to elaborate and better understand topics on their own terms and in their own way (Jansen, 2011). IBL is not only an intrapersonal skill but also very much an important interpersonal skill to foster and develop because of the importance of fostering working relationships with others. The group setting is perfect for teaching students to pursue different roles and ultimately developing their own pedagogical skills and interpersonal skills.

The question of "Why use IBL?" is important, as the method should be supported by its effectiveness. Some believe that IBL is the most effective learning strategy because it displays ideas in an organic manner (Bybee, 2002; Prince & Felder, 2007; Crawford, 2007; Layman, 1996). Allowing students to form ideas, gather relevant information and test theories on their own provides them with the opportunity to engage in the scientific method. Students and teachers engaged in scientific concepts and exploring scientific questions are involved with the pedagogical style of IBL (Vernaza-Hernández et al., 2012).

Student Engagement

Defining IBL as a teaching strategy can be challenging because it has no universal definition and IBL may have a different pedagogical outlook depending on the subject matter. The National Science Teachers Association in the U.S.A. describes inquiry as: "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (Retrieved August 3, 2017). In other words, it is an engagement in scientific research to better understand the questions and answers with which they are confronted. Furthermore, Krause and Coates (2008) found that engagement comes from higher quality activities. Providing students with the opportunity to struggle and overcome problems that challenge them will grant them a richer experience. Additionally, Kuh et al. (2006) described engagement as taking part in effective academic opportunities. Developing projects that provide students with the opportunity to learn the requisite material but in a fun and interesting manner can only lead to greater engagement.

Role of the teacher

It is understood that the role of the teacher has an impact on the development of the students, as they are the ones who guide the program and provide the learning opportunities for their students. In recent years teaching styles have evolved from teacher-centered learning to student-centered learning. One major difference between the two teaching styles is that teacher-centered learning is controlled by the teacher with the students having little input (Dollard & Christensen, 1996). Furthermore, students in a teacher-centered classroom may often be motivated by extrinsic motivation which is designed to guide student behaviour. Rather than reinforcing student inquiry and curiosity the focus is shifted towards the completion of a task to receive a desired result (Chance, 1993).

The opposite viewpoint of a teacher-centered approach is one where the students' well-being is placed ahead of the teacher's own personal agenda and the student's voice is valued and championed, that is more of a student-centered approach. The methods that are more common in a student-centered approach are projects that allow freedom and IBL activities (Parr & Edwards, 2004). Freedom of choice can take shape in different ways within the classroom and one of the ways can be allowing students the autonomy to guide their own learning (Good & Brophy, 2003). Opportunity to choose for oneself is one of the main tenets of IBL as students are encouraged to explore and develop their own ideas and expound upon topics that were meant as a jumping off point not a prescriptive.

The impact that a teacher can have on IBL is tremendous as the teacher is the one who acts as the facilitator and provides learning opportunities for students for which to engage. A major key in implementing and maintaining an IBL classroom is the development of interpersonal relationships. The relationships build and foster strong connections between the teacher and student which allow the student to explore learning in their own way (Dollard & Christensen, 1996). The development of a student-centered learning environment helps students realize they are part of the whole and this contributes to a positive group dynamic (Bloom, Perlmutter & Burrell, 1999, p. 134). Behaviours may still occur but it is the responsibility of the students to help manage these behaviours through community building practices set out by the teacher that may include the entire group (Garrett, 2008). For example, the community building program Tribes where participants discuss issues by delivering their feelings using "I" messages are great at developing social skills while helping to solve problems that may arise (Gordon, 1974).

Lastly, the teacher must develop intrinsic motivation in the classroom as a strategy to minimize classroom issues and promote learning interests from within rather than promoting external motivation (DeVries & Zan, 1994). Another result of promoting greater external motivation for students is the subsequent autonomy that can arise because students see how their individual choices are valued and can bring rewards to themselves therefore motivating the inquisitive mind and promoting deeper learning (Brophy & Good, 2003).

Additionally, the teacher is charged with developing, modeling and mentoring the progression of the student and their interpersonal relationships. Interpersonal relationships are vital in the IBL process because interpersonal skills help students achieve greater resiliency and improve the likelihood of potential future endeavours being successful (Dweck & Leggett, 1988). Another result of students' and adults' interpersonal relationships is the adoption of not only habits but also motives that ensure students maintain proper behaviours during the according context (Maccoby, 1992). Proper behaviour in the school setting is extremely important as students' motivations rely heavily on structure and consistency. A review of studies by Wentzel (1997) showed that positive and supportive relationships have a direct correlation to students' ability to adapt and motivate toward their schooling experience. Additionally, research shows that if students have parents who exhibit strong interpersonal skills by helping with homework and participating in the child's extracurricular activities then the child is more likely to demonstrate a higher level of interpersonal skills (Ryan, 1995). Due to the highly collaborative nature of IBL, interpersonal skills are beneficial since information gathering can happen in many different forms including discussions and group learning.

Furthermore, pleasant student teacher relationships positively correlate with the student's perception towards school (Wentzel, 1994; Wentzel & Asher, 1995). Moreover, peer to peer positive interpersonal relationships have been positively correlated with satisfactory school experiences, proper social behaviour and effective goal setting (Wentzel, 1994; Wentzel & Asher, 1995). Likewise, teachers developing positive and caring relationships with students are more likely to create students who internalize and display positive expectations than teachers that create negative environments (Grusec & Goodnow, 1994). Moreover, Lewin found, similarly to the teaching model of IBL, that when students were granted autonomy they displayed greater resiliency when it came to completing tasks than did students who worked with adults who presented too much control or too little (Lewin, Lippitt, & White, 1939).

Constructivism

Inquiry Based Learning can be traced back in many of its principles to constructivism. The constructivist approach postulates that people produce, and form knowledge based on their experiences (Bada & Olusegun, 2015). Knowledge is built upon experiences that have already occurred and the new concepts or events that they encounter (Cannella & Reiff, 1994; Richardson, 1997). Furthermore, much aligned to how inquiry learning is geared towards influencing students' learning through questioning, the constructivist approach is tailored in the same way as it is geared towards involvement in the learning process and not rote learning or repetitive tasks (Kroll & LaBoskey, 1996). In the constructivist model the teacher is not simply the dispenser of knowledge but someone who is along for the journey with the learner helping shape their experience and make it as memorable, impactful and as fruitful as possible. The constructivist model is there to provide learners with the tools necessary to explore educational opportunities that present themselves. This is the concept that Freire (1968), a Brazilian educator and philosopher, posited as the “banking model” where deposits are viewed as positively impacting a student's learning therefore the greater the number of deposits the better.

We can look at different models of constructivism by looking more closely at Piagetian or Psychological Constructivism. This approach focuses on the development of the child when encountering and overcoming dilemmas brought to their attention by their teacher or encountered from everyday life (Abdal-Haqq, 1998). Additionally, this learning model deems instructional practices that challenge and encourage critical thinking as most impactful and successful for student development (Richardson, 1997). The theory may struggle in explaining why some students fail as it assumes that strategies, like that of IBL, are always successful because of the ingrained curiosity and drive within every student and cannot fail because of issues such as gender, race or class (Vadeboncoeur, 1997). Vadeboncouer explains that this might be a limitation because of its lack of attention or understanding that the social context might have on the development and education of a child.

Social constructivism is another way to look at the impact inquiry learning has on the development of the learner. This is the concept of a mutual interchange between students and the curriculum in the educational process (Steffe & Gale, 1995). Therefore, the goal is to include students in their own social and educational development, emphasizing that the student is impacted by the social impact of studying and exploring science and not just being exposed to pre-discovered knowledge or truths. Vygotsky

(1978) explained that the development of the cognition came because of social interactions where the student would "make meaning" in their experiences (p. 76). This is in direct accordance to the fundamentals and aspirations of the IBL model. The IBL model strives to promote critical thinking skills by either presenting or manufacturing problems that students must solve. Furthermore, the goal is to encourage students to work positively with their peers and use the skills at their disposal, be it their own skills or the skills of their peers, and work to achieve success. Vygotsky goes on to say that unequal skill levels are possible and by matching peers of all different abilities the stronger peers will help bring along those peers who may be less advanced. Scaffolding is also an important strategy for students as it is most effective when matched to the needs of the learner (Wood & Middleton, 1975). The IBL teaching strategy is designed to provide students with assistance, where needed, and help support them as they continue their journey of learning and inquiry.

Social Cognitive Theory

Learning within the classroom can be completed in many ways and analyzed through the lens of many different theories. One of the ways the process of IBL can be analyzed is through the Social Cognitive Theory (SCT). Bandura's (1989) Social Cognitive Theory examines how people interact with learning and describes the process as neither entirely intrinsic nor extrinsic. People are motivated by a multitude of factors that provide feedback that are found within a learning environment (Bandura, 1989). Inquiry learning is specifically tailored and designed for providing students with opportunities to explore and interact with learning on their own terms to gain the knowledge they feel is required. Previous research has shown that human characteristics do not necessarily reflect student capabilities in academia (McClelland, 1973). Thus, the student can, and does, ultimately determine whether they are going to succeed in the school setting (Mischel, 1973). Bandura and Simon (1977) go on to say that it takes more than intention or a will to succeed if students lack the capability to self-regulate their own personal behaviour.

Social Cognitive Theory helps explain the role of IBL in the classroom and the impact it has on students and their achievement by providing understanding of what motivates students. The teacher's responsibility in an IBL classroom is to model expectations and create an environment where students feel comfortable to explore. The classroom where students' ideas are challenged, encouraged to improve and refined for even greater inspection is an effective model of the inquiry teacher (Scardamalia, 2002). The skill of inquisition is fostered, praised and refined by the educator who is trying to instill a behaviour in the student that is exemplified not only by the teacher but also from the students participating in the learning environment.

Merriam-Webster defines cognition as "of, relating to, being, or involving conscious intellectual activity (such as thinking, reasoning, or remembering)" (Retrieved, September 6, 2017). The thinking process is ingrained with inquiry as is expression of thought. Examination of thought is what drives IBL to new heights and greater understanding. Scardamalia found that classrooms where ideas are viewed as the main currency are where IBL will thrive best (2002). These experiences lead to acquiring knowledge and further developing and improving the cognition of the student involved. Students are not only encouraged to think about the inquiring topic but also asked to reflect on the process, from the beginning to the end, and ponder how they came to a specific answer and what the process in its entirety says about their thinking and cognition (Capacity Building Inquiry, 2013).

Action Research

Participatory Action Research (PAR) is a "methodology enabling researchers to work in partnership with communities in a manner that leads to action for change" (Baum, MacDougall & Smith, 2006, p. 854). The purpose of action research is to initiate a change and be part of that change and then reflect upon the experience (2006). These researchers go on to mention another important point in that the participants in the study become partners in the process and these partners help better shape the educational practice which in turn improves the student's educational experience. Furthermore, the article describes Freire's feelings towards the human consciousness as a reflection on material reality and that critical reflection is already taking place once it enters the reflectors consciousness (1972). The importance of action research cannot be overstated as it allows for the current evaluation of a practice which is incredibly important for developing future more impactful and efficient strategies.

Action research can lead to the development and improvement of skills for those that are involved in the process. A study by Mitchell et al. (2009), looked at the impact of Collaborative Action Research (CAR) on beginning teachers and they found that CAR can be helpful in promoting growth amongst newer teachers. Furthermore, Mitchell et al. also support the concept that CAR can be tied to a more informed pedagogical practice and how CAR can support the professional development of a teacher. Schon (1983) discussed the use of action research and the impact it can have on encouraging reflective practice for teachers. This essentially describes the purpose for pedagogical action research or CAR which is inevitably focused on promoting practice to improve the experience of the student. This is also confirmed by McNiff who supports this feeling by describing action research as a commitment to the improvement of educational practices (McNiff, 2013: McNiff, 2016). Additionally, CAR is beneficial to students by empowering teachers to incorporate active learning within their theoretical framework of education to better serve students both academically and personally (Mitchell, 2009). Focusing on the task allows the roles to be shared and students to participate in the process and allows all parties to focus on the result (Mitchell, 2009). The results of the study are there to help improve the experience and not point the finger (Ulichny & Schoener 1996).

The effectiveness of alternative learning styles such as Problem Based Learning (PBL) is documented in studies like the one by Dods which discusses the impact on student achievement for post-secondary courses of PBL in comparison to the more traditional lecture style (1997). Dods goes on to discuss how the different styles, traditional versus a more hands-on approach, have different viewpoints. The more student-lead model allows students to interact directly with material, thus potentially making it more meaningful and therefore more likely to be retained. Conversely, the instructor lead model does allow for greater overall coverage of the topics. However, his action research concluded there were potentially slightly improved results for students with PBL but further investigation was required.

Effectiveness of Science Attitude Surveys

There are many positives impacts that are proposed by those who have supported and researched the effectiveness of IBL on student learning. There are however some potential issues with IBL and the surveys that purport to support its effectiveness. At issue is the psychometric qualities of the test. There is research that has shown that attitude tests, like that of the SAI II, can often have poor psychometric qualities (Munby 1982, 1997 & Gardner 1975,1995 & 1996). This means that it is difficult to measure the reliability and validity of the test. This would then make it difficult to determine the impact IBL is having on students and how it might be affecting their perception of science. Test like the SAI II may represent more of a rough overall sketch of the students' feelings and opinions about science in general at both the cognitive and emotional level (Kind, Jones, & Barmby 2007). Furthermore, the teaching of science may be characterized more by the impact of the teacher on the students' enjoyment of their science course then having a positive attitude towards science. Kind, Jones and Barmby go on to discuss the conundrum of determining what exactly is being studied and measured. Are the test measuring students' attitudes towards science in the classroom, or at home or something even more general? Also, are students being asked to review science the discipline or those who practice it as scientists (Ramsden, 1998). Kind et al. also called into question some of the wording of the questions as inappropriate at times for the desired target audience of the test (2007). Examples like the following from the SAI do not necessarily paint a clear picture: "I want to be a scientist," does not directly correlate with students' attitude toward science it is simply a preference in their potential future vocation. This could speak to the relative cognitive immaturity in regard to what science is as a subject and career for students of this age. Additionally, the statement "Science is rigid," does not directly reflect one's attitude toward science but may simply comment on the discipline itself.

Dr. Hugh Munby, from the University of Queens in Kingston, Ontario wrote several articles regarding the effectiveness of the SAI and the SAI II. Munby described several issues that he found with the SAI II (1997). First, there is little to show exactly what this scale measures. Does it measure a student's attitude towards science or science instruction, science as an experience? Moreover, there is no clear evidence that each measure is a question measuring specifically and directly a student's attitude toward science. To test the construct validity of the scale the test used a panel of judges' techniques. The American Psychological Association does not recognize this technique for validity confirmation (1999). The issue with this strategy for determination of validity is that it involves determining the meaning to both the participant and the judge of each response something that is obviously difficult for a test that only provides respondents with the 5-point Likert scale. Munby goes on to say that "serious criticisms" were ignored from the original Scientific Attitude Instrument (SAI). Furthermore, that the SAI II should be more concerned with developing a construct where we can measure the validity more accurately. Munby provides two strategies to build upon the SAI and develop a valid test: 1) to collect the results of the test and their reports on reliability and validity; and 2) revising theoretical structures and aligning those with the test standards from organizations.

Munby (1997) recommends those involved with the SAI: "assume that the SAI is founded on something like a conception of good science and that the tenets of science are similar in kind to those of all disciplined inquiry. Thus, Item 25 — "Scientists must report exactly what they observe"—becomes a recommendation that we attempt to account for all available information when we are designing or revising an instrument" (p. 340).

The Effectiveness of Inquiry Based Learning

Why Minimal Guidance During Instruction Does Not Work:

De Groot (1946/1965) as well as Chase and Simon (1973) conducted studies on chess players and they found that expert chess players are much better at recreating briefly viewed game situations than are beginner players. If the chess configurations were completely random then expert players were not more likely to recreate the board compared to novices. What this tells us is that problem-solving situations like this are more successfully navigated by those who have experience in these situations which they can draw upon to make the most informed and wise decision possible. When comparing this to the IBL model then we see that having students' complete activities without a base knowledge of the subject creates the potential that they may not have the necessary knowledge and available working memory, along with long term memory, to complete the activity because they must focus intently on the task at hand (Kirschner, Sweller & Clark, 2006). Their peers may have already been instructed on the subject and developed their long-term memory and thus able to incorporate ideas into their working memory during the IBL process.

Another issue with IBL is its taxation on the working memory (Sweller 1999, Sweller van Merrirenboer & Paas 1998). The heavy load on the working memory created by IBL situations does not promote accumulation of knowledge into long-term memory. Learners may be working on a problem for an extended period and no information may be gained or transferred to the long-term memory (Sweller, Mawer and Howe 1982). This goes against the main idea behind the instructional practice of IBL which is intended to provide students with a rich learning experience that has greater meaning and a superior impact on them as learners because it was experienced actively first-hand.

Who is to blame for the focus on self-guided instruction in the educational system? The theory of constructivism has a great deal to do with the development of this teaching strategy (Steffe & Gale 1995). Constructivism is of the thought that knowledge is constructed by learners therefore minimal information is required for the learner to interact in the learning experience. Also, each learner is unique and that teaching in a whole class approach will not accommodate for the individuality of each learner. Furthermore, learners can construct schemas with or without the entire learning picture and learners desire to construct schemas of their learning experiences (Kirschner, Sweller & Clark, 2006). Therefore, for the student to be successful it is ultimately in their best interest to aid them in the development of the schemas that are set around specific learning expectations that can be enhanced by inquiry strategies but not solely rely upon inquiry as a means of instruction.

Another problem with the constructivist view is that instruction, in this case IBL, should only focus on the method and process and that no attention should be paid to the facts and theories that surround a specific learning goal (Handelsman et al., 2004 & Hodson, 1988). Learning through personal experience, a more student-centered approach, would produce a superior learning result compared to the teacher centered approach which is more concerned with dispensing facts and theories into the mind of the student. It may be a mistake to assume that simply learning the process and methods of completing a task means that the learner absorbs the facts and theories that are involved with the learning goal (Kirschner et al., 2006).

Hurd (1969) discussed the impact of what the science teacher might see as the rationale of the scientist. He explained that the teacher might feel science instruction "should be a mirror image of a science discipline, regarding both its conceptual structure and its patterns of inquiry. The theories and methods of modern science should be reflected in the classroom...classroom operations should be in harmony with its investigatory processes…" (p.16). Hodson (1988) explains this rationale as "…the attainment of certain attitudes, the fostering of interest in science...the learning of scientific knowledge...were all to be approached through the methodology of science, which was, in general, seen in inductive terms" (p.22). The issue with this viewpoint is that it does not consider that there is a wide gap between the mature scientist who has an extensive base of knowledge and a novice science student who has a limited base of knowledge. The inquiry experience for these two learners will be far different as the experienced scientist already has the scaffolding in place to build upon for his new inquiry experience whereas the novice learner has no previous infrastructure to build upon and facilitate new learning connections.

Unguided instruction has been popular and fallen under many different names throughout the course of educational research and development. Some of the different tags for unguided learning over the years are discovery learning, experiential learning, problem-based and inquiry learning (Kirschner et al., 2006). Whatever the name, these unguided approaches and those that support them seem to either avoid or ignore the evidence that has shown a more favourable result to learning by those using a guided approach (Mayer, 2004). In fact, many studies have observed that those students who are ultimately more successful in unguided learning situations will eventually receive a great deal of instruction through methods such as scaffolding, modeling, paraphrasing and collaborative dialogue (Aulls, 2002). A negative outcome of either not receiving this direct guided instruction, or receiving it too late, is hopelessness or frustration that can set in for students who do not receive the support they need when partaking in unguided reading (Hardiman, Pollatsek, & Well, 1986; Brown & Campione, 1994).

CHAPTER 3

METHODOLOGY

Research Design

Using a quasi-experimental design with pre- and post-surveys, an action research case study applying IBL instruction with grade 7 students in science class was conducted at a school located in Southwestern, Ontario. The Research Ethics Board granted approval for this project. Individual consent was not needed as secondary data was used.

From September 2015 to June 2016, 49 grade 7students ranging from ages 12-13 were observed. There were 22 males and 27 females in the study group. Students were prompted to ask, and answer questions based on The Ontario Curriculum Grades 1-8 Science and Technology in English. Additionally, the grade 7 students had access to Science and Technology Perspectives 7 series by the publisher Nelson. The student science self-efficacy questionnaire, “What is your Attitude toward Science?” was completed at the beginning and end of a unit supplied by Richard Moore (Moore & Foy, 1997).

The questionnaire dealt with students’ attitudes in science. Students also completed open-ended questions at the end of the unit. Those questions were: “My favourite part of science class is...because…; My least favourite part of science class is...because…; I enjoy studying science because…” Participation in the study was voluntary; however, all students received the same instruction using the IBL method. Students not participating in the study were not punished. Not participating in the study had no impact on student assessment or their ability to participate in all curriculum based activities.

The open-ended questionnaire allowed students to share their feelings regarding the learning experience. The questions were initiated at the end of the school year. The open-ended questions were compared to assess students' feelings toward science based on the IBL teaching style.

Each unit was divided into three sections per the textbook. The classes were asked to brainstorm questions pertaining to the respective topics based on their interests or observations after reviewing the textbook chapters. A list of questions was then compiled and used for potential research projects for students during the unit. Additionally, students were asked to complete a hands-on project that centers on a main topic around the respective unit. Students were given the goal of the project but were not instructed how to achieve the final product and had to inquire independently. If student topics were duplicated, the students were asked to research different components of the topics.

Research Procedure and Participants

Participant Selection

There were 22 males and 27 females in grade 7. No control group was used due to the unethical grounds of providing a potentially beneficial educational intervention to one group of students and not the other group.

Design

Part 1: Survey. The study consists of a survey called the Scientific Attitude Inventory (SAI II). The student science self-efficacy questionnaire, "What is your Attitude toward Science?" was completed at the beginning and end of the school year. The questionnaire dealt with students' attitudes in science. The survey was used to determine if there was any change in students' attitudes towards science from the beginning of the school year until the end of the year while partaking in IBL activities. Participation in the study was voluntary; however, all students received the same instruction using the IBL method.

Part 2: Open-ended questions. This part of the study involved using the questions below and eliciting responses from students with specific details and thoughts. The response took place at the end of the school year. Each student could write their response and use images to support their idea and their responses were kept anonymous using student numbers. The question used was: “My favourite part of science class is...because…; My least favourite part of science class is...because…; I enjoy studying science because…”

Instrumentation

Part 1: Scientific Attitude Inventory. The study allows the teacher to quantify the data using descriptive statistics. The survey used was the Scientific Attitude Inventory (SAI II). The survey was developed by Richard Moore of the University of Miami of Ohio, in 1970 (Moore & Foy, 1997). The survey consists of 40 gender neutral position statements using a five-point Likert scale (Scale Range: A= strongly agree, B= agree, C= neither agree or disagree, D= disagree, and E= strongly disagree). The forty position statements were opposing negative and positive statements. For example: Question #36 said “I would like to be a scientist...” Question # 22 said “I do not want to be a scientist.” The groups of statements reflect scientific concepts such as the theories of science and whether theories are set and unchangeable or are subject to change if new ideas are presented. Whether science can specifically and accurately answer all questions or is there phenomena unanswerable by science. Whether it is important to be objective and open minded to all ideas or that scientists are always right and there is no room for subjectivity. Whether the goal of science is to produce new ideas and explain events or if it is there to serve people and make their lives better. Whether public awareness and understanding improves science or if the public involvement has no impact on promoting scientific ideas. Whether working in science would be rewarding and fulfilling or if it would be disappointing and unsatisfying.

To score the test I looked at the set of questions revolving around the same principle, for example: whether the student would enjoy being a scientist. One of the statements was phrased in a positive manner while the other statement was phrased in a negative manner. I took the initial score and compared it to the follow-up score for both the positive and negative statement. If the positive statement score went up and the negative statement score went down from the first to second recording, then that was flagged. The reverse was also noted, meaning that if the positive score went down and the negative score went up it was deemed noteworthy.

Validity

The SAI II is based on the SAI which was developed by Sutman and Moore in 1970. The test was reviewed by judges and was deemed successful and the construct validity was supported in the original field test (Moore & Foy, 1997).

Reliability

The following is from Moore's text (p.333):

Reliability A split-half reliability coefficient was computed for the entire group of 557 respondents. Application of the Spearman Brown correction for split-half reliability to the correlation coefficient yields a reliability coefficient of .805. Cronbach's alpha reliability coefficient is .781 for this group.

Part 2: Journal Response Questions

The students answered the questions mentioned above "My favourite part of science class is...because…; My least favourite part of science class is...because…; I enjoy studying science because…" Student responses were then analyzed for themes such as "hands on experiments," or "using google drive" or "because you learn new things." The responses were put into categories.

Data Collection

The data collection took place throughout the 2015-2016 school year. There were 3 separate occasions, two to collect the survey responses and one to collect journal responses. The students were provided with approximately 15 minutes for each task. All data were collected by June 2016.

Ethical Considerations

Informed Consent. It is my responsibility to ensure that participants realize they have the option to participant in the study and that I explain clearly the nature of the study and any possible dangers that may occur as a participant in the study. This information is provided to ensure that participants are treated fairly. Participants were also informed that they have the right to withdraw at any time and that any previous data collected from them will be terminated (Gay, Mills & Airasian, 2009). To complete the study, participants will be asked to provide consent to use the data that has been collected by the teacher.

Freedom from Harm. It is my responsibility to protect participants against any risks that may compromise their own personal privacy and confidentiality. I must also ensure that I do not collect information from participants without them knowing or without seeking the appropriate permission (Gay, Mills & Airasian, 2009).

Confidentiality. It is my responsibility to ensure that information obtained from participants is kept private (Gay, Mills & Airasian, 2009).

CHAPTER 4

ANALYSIS OF RESULTS

The surveys provided to the students were examined using SPSS. Additionally, the participants' responses to the journal questions were summarized and categorized (see appendix C).

Participant Findings

Forty-nine participants were included in the study following inclusion criteria involving completion of both the initial survey and the follow-up survey. Table 1 shows the Between-Subject Factors with Gender 1 representing males and Gender 2 representing females. These tables show the breakdown of participants and the means of their responses for both genders for a pre- and post-survey.

Table 1. Between-Subjects Factors.

	N
Gender 1 (M)	22
Gender 2 (F)	27

Quantitative Results

Statistics for Question 1: Questions deal with theories and laws of science and whether or there are absolute truths in science.

Table 2. Descriptive Statistics for Set of Questions 1

	Gender	Mean	Std. Deviation	N
Q1A_Pr	1	4.1212	.54961	22
	2	3.9753	.52237	27
	Total	4.0408	.53417	49
Q1A_Post	1	4.1970	.75354	22
	2	4.1111	.63381	27
	Total	4.1497	.68401	49
Q1B_Pr	1	3.0000	.64242	22
	2	2.8889	.54694	27
	Total	2.9388	.58797	49
Q1B_Post	1	2.9091	.81767	22
	2	2.7407	.59437	27
	Total	2.8163	.70073	49

Table 2 shows the mean responses for the Likert scale for both genders for a pre- and post-survey for question 1.

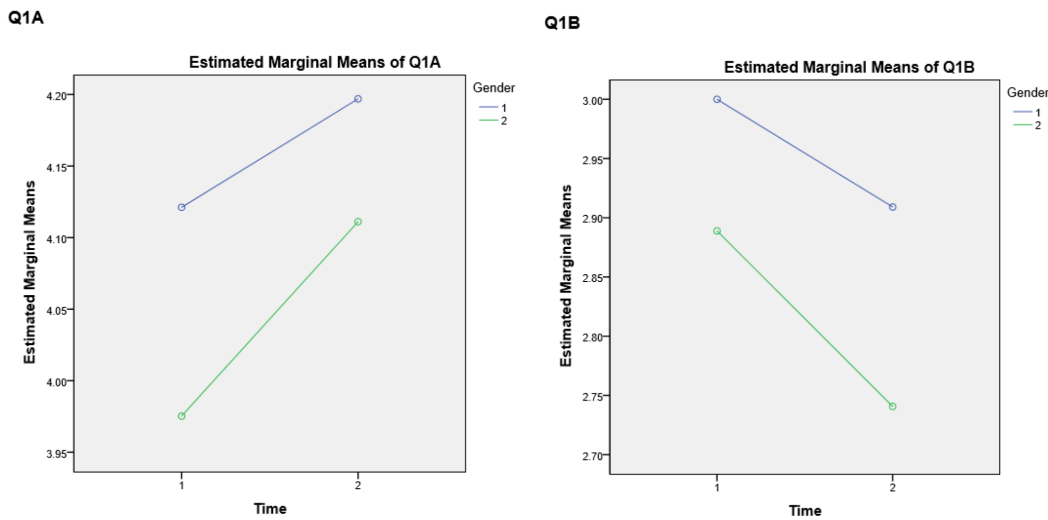


Figure 1. Comparative graph showing responses for both males and females for the pre- and post-survey for question 1.

Figure 1 visualizes the comparison of responses for both males and females for the pre- and post-survey questions. These line graphs show that participants were more agreeable with positive statements from the survey over time and were less agreeable with negative statements over that same period. This demonstrates that there is a trend in favour of believing that science is about testing theories and not truths.

Table 3. Univariate Tests for set of Questions 1.

Source	Measure	Type III Sum of Squares	Df	Mean Square	F	Sig.
Time	Q1A: Sphericity Assumed	.271	1	.271	.855	.360
	Q1A: Greenhouse-Geisser	.271	1.000	.271	.855	.360
	Q1A: Huynh-Feldt	.271	1.000	.271	.855	.360
	Q1A: Lower-bound	.271	1.000	.721	.855	.360
	Q1B: Sphericity Assumed	.346	1	.346	1.131	.293
	Q1B: Greenhouse-Geisser	.346	1.000	.346	1.131	.293
	Q1B: Huynh-Feldt	.346	1.000	.346	1.131	.293
	Q1B: Lower-bound	.346	1.000	.346	1.131	.293
Time* Gender	Q1A: Sphericity Assumed	.022	1	.022	.069	.794
	Q1A: Greenhouse-Geisser	.022	1.000	.022	.069	.794
	Q1A: Huynh-Feldt	.022	1.000	.022	.069	.794
	Q1A: Lower-bound	.022	1.000	.022	.069	.794
	Q1B: Sphericity Assumed	.020	1	.020	.065	.800
	Q1B: Greenhouse-Geisser	.020	1.000	.020	.065	.800
	Q1B: Huynh-Feldt	.020	1.000	.020	.065	.800
	Q1B: Lower-bound	.020	1.000	.020	.065	.800
Error (Time)	Q1A: Sphericity Assumed	14.910	47	.317		
	Q1A: Greenhouse-Geisser	14.910	47.000	.317		
	Q1A: Huynh-Feldt	14.910	47.000	.317		
	Q1A: Lower-bound	14.910	47.000	.317		
	Q1B: Sphericity Assumed	14.391	47.000	.306		
	Q1B: Greenhouse-Geisser	14.391	47.000	.306		
	Q1B: Huynh-Feldt	14.391	47.000	.306		
	Q1B: Lower-bound	14.391	47.000	.306		

Table 3 shows the results of the test for significance for both pre- and post-survey within subjects (males and females) and between subjects (comparing males and females). There is no statistical significance seen in this subset of questions (p>.05).

Statistics for Question 2: Questions deal with whether science can provide answers to all questions.

Table 4. Descriptive Statistics for Set of Questions 2.

	Gender	Mean	Std. Deviation	N
Q2A_Pr	1	4.1970	.64782	22
	2	4.2222	.44337	27
	Total	4.2109	.53875	49
Q2A_Post	1	4.2424	.70660	22
	2	3.9630	.69389	27
	Total	4.0884	.70637	49
Q2B_Pr	1	3.0758	.91970	22
	2	2.9877	.69480	27
	Total	3.0272	.79593	49
Q2B_Post	1	3.0758	1.10282	22
	2	2.5802	.64445	27
	Total	2.8027	.90502	49

Table 4 shows the mean responses for the Likert scale for both genders for a pre- and post-survey for question 2.

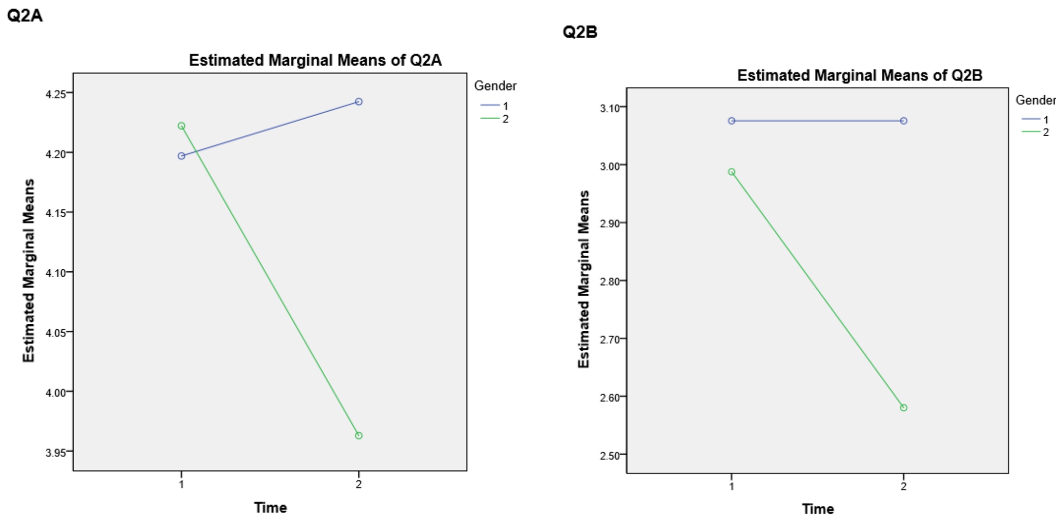


Figure 2. Comparative graph showing responses for both males and females for the pre- and post-survey for question 2.

Figure 2 shows that males were more agreeable, and females were less agreeable with statements that say science is limited in its ability to provide answers. While males were neither agreeable nor disagreeable, females were more disagreeable with statements that claim science can provide all correct answers.

Table 5. Univariate Tests for Question 2.

Source	Measure	Type III Sum of Squares	Df	Mean Square	F	Sig.
Time	Q2A: Sphericity Assumed	.277	1	.277	1.226	.274
	Q2A: Greenhouse-Geisser	.277	1.000	.277	1.226	.274
	Q2A: Huynh-Feldt	.277	1.000	.277	1.226	.274
	Q2A: Lower-bound	.277	1.000	.277	1.226	.274
	Q2B: Sphericity Assumed	1.006	1	1.006	2.360	.131
	Q2B: Greenhouse-Geisser	1.006	1.000	1.006	2.360	.131
	Q2B: Huynh-Feldt	1.006	1.000	1.006	2.360	.131
	Q2B: Lower-bound	1.006	1.000	1.006	2.360	.131
Time* Gender	Q2A: Sphericity Assumed	.563	1	.563	2.489	.121
	Q2A: Greenhouse-Geisser	.563	1.000	.563	2.489	.121
	Q2A: Huynh-Feldt	.563	1.000	.563	2.489	.121
	Q2A: Lower-bound	.563	1.000	.563	2.489	.121
	Q2B: Sphericity Assumed	1.006	1	1.006	2.360	.131
	Q2B: Greenhouse-Geisser	1.006	1.000	1.006	2.360	.131
	Q2B: Huynh-Feldt	1.006	1.000	1.006	2.360	.131
	Q2B: Lower-bound	1.006	1.000	1.006	2.360	.131
Error (Time)	Q2A: Sphericity Assumed	10.625	47	.226		
	Q2A: Greenhouse-Geisser	10.625	47.000	.226		
	Q2A: Huynh-Feldt	10.625	47.000	.226		
	Q2A: Lower-bound	10.625	47.000	.226		
	Q2B: Sphericity Assumed	20.037	47.000	.426		
	Q2B: Greenhouse-Geisser	20.037	47.000	.426		
	Q2B: Huynh-Feldt	20.037	47.000	.426		
	Q2B: Lower-bound	20.037	47.000	.426		

Table 5. Univariate Tests. This table shows the results of the test for significance for both pre- and post-survey within subjects (males and females) and between subjects (comparing males and females). There is no statistical significance seen in this subset of questions ($p>.05$).

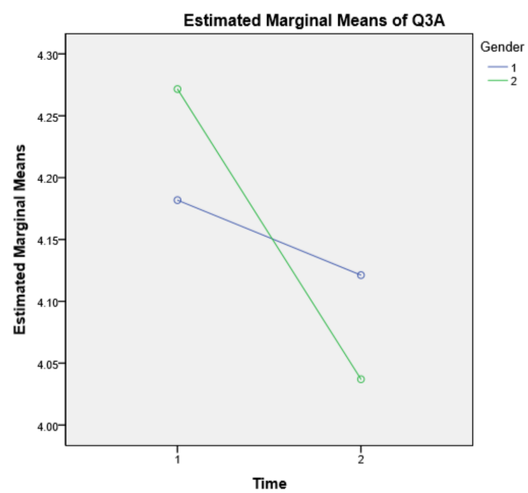
Statistics for Question 3: Questions deal with the thought processes associated with science and whether one has a willingness to alter their opinion or know all scientific truths:

Table 6. Descriptive Statistics for Set of Questions 3.

	Gender	Mean	Std. Deviation	N
Q3A_Pr	1	4.1818	.72541	22
	2	4.2716	.48071	27
	Total	4.2313	.59785	49
Q3A_Post	1	4.1212	.66305	22
	2	4.0370	.57981	27
	Total	4.0748	.61337	49
Q3B_Pr	1	2.2727	.87672	22
	2	2.2840	.73207	27
	Total	2.2789	.79158	49
Q3B_Post	1	2.1212	.73855	22
	2	2.1235	.66118	27
	Total	2.1224	.68952	49

Table 6 shows the mean responses for the Likert scale for both genders for a pre- and post-survey for question 3.

Q3A



Q3B

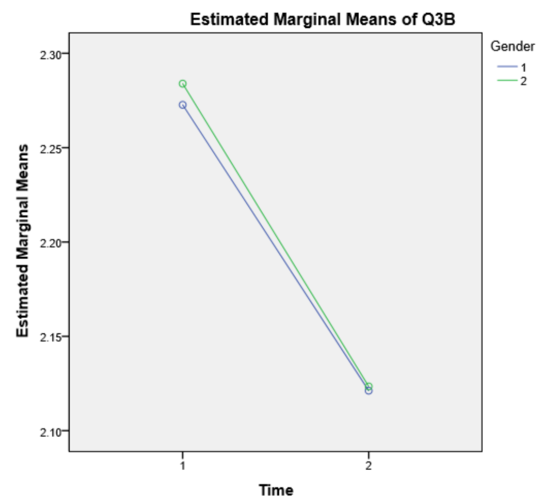


Figure 3. Comparative graph showing responses for both males and females for the pre- and post-survey for question 3.

Figure 3 shows that participants were less agreeable with both positive and negative statements over that same period. This trend demonstrates that students were less willing to agree with the importance of an openness to alter one’s beliefs regarding truths and they also trended toward less agreement in needing to know all scientific truths.

Table 7. Univariate Tests for question 3

Source	Measure	Type III Sum of Squares	Df	Mean Square	F	Sig.
Time	Q3A: Sphericity Assumed	.528	1	.528	3.577	.065
	Q3A: Greenhouse-Geisser	.528	1.000	.528	3.577	.065
	Q3A: Huynh-Feldt	.528	1.000	.528	3.577	.065
	Q3A: Lower-bound	.528	1.000	.528	3.577	.065
	Q3B: Sphericity Assumed	.590	1	.590	1.807	.185
	Q3B: Greenhouse-Geisser	.590	1.000	.590	1.807	.185
	Q3B: Huynh-Feldt	.590	1.000	.590	1.807	.185
	Q3B: Lower-bound	.590	1.000	.590	1.807	.185
Time* Gender	Q3A: Sphericity Assumed	.183	1	.183	1.242	.271
	Q3A: Greenhouse-Geisser	.183	1.000	.183	1.242	.271
	Q3A: Huynh-Feldt	.183	1.000	.183	1.242	.271
	Q3A: Lower-bound	.183	1.000	.183	1.242	.271
	Q3B: Sphericity Assumed	.000	1	.000	.001	.969
	Q3B: Greenhouse-Geisser	.000	1.000	.000	.001	.969
	Q3B: Huynh-Feldt	.000	1.000	.000	.001	.969
	Q3B: Lower-bound	.000	1.000	.000	.001	.969
Error (Time)	Q3A: Sphericity Assumed	6.939	47	.148		
	Q3A: Greenhouse-Geisser	6.939	47.000	.148		
	Q3A: Huynh-Feldt	6.939	47.000	.148		
	Q3A: Lower-bound	6.939	47.000	.148		
	Q3B: Sphericity Assumed	15.344	47.000	.326		
	Q3B: Greenhouse-Geisser	15.344	47.000	.326		
	Q3B: Huynh-Feldt	15.344	47.000	.326		
	Q3B: Lower-bound	15.344	47.000	.326		

Table 7 shows the results of the test for significance for both pre- and post-survey within subjects (males and females) and between subjects (comparing males and females). Set 3, positive statements, show that participant responses are approaching statistical significance (p= .065).

Statistics for Question 4: Questions deal with what role science serves and whether it is of theoretical or practical value:

Table 8. Descriptive Statistics for Set of Questions 4.

	Gender	Mean	Std. Deviation	N
Q4A_Pr	1	4.1364	.64782	22
	2	4.0000	.62017	27
	Total	4.0612	.62979	49
Q4A_Post	1	3.9242	.63356	22
	2	3.8765	.67399	27
	Total	3.8980	.64980	49
Q4B_Pr	1	4.0455	.77183	22
	2	3.5926	.60858	27
	Total	3.7959	.71627	49
Q4B_Post	1	4.0000	.85449	22
	2	3.4691	.72947	27
	Total	3.7075	.82393	49

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Table 8 shows the mean responses for the Likert scale for both genders for a pre- and post-survey for question 4.

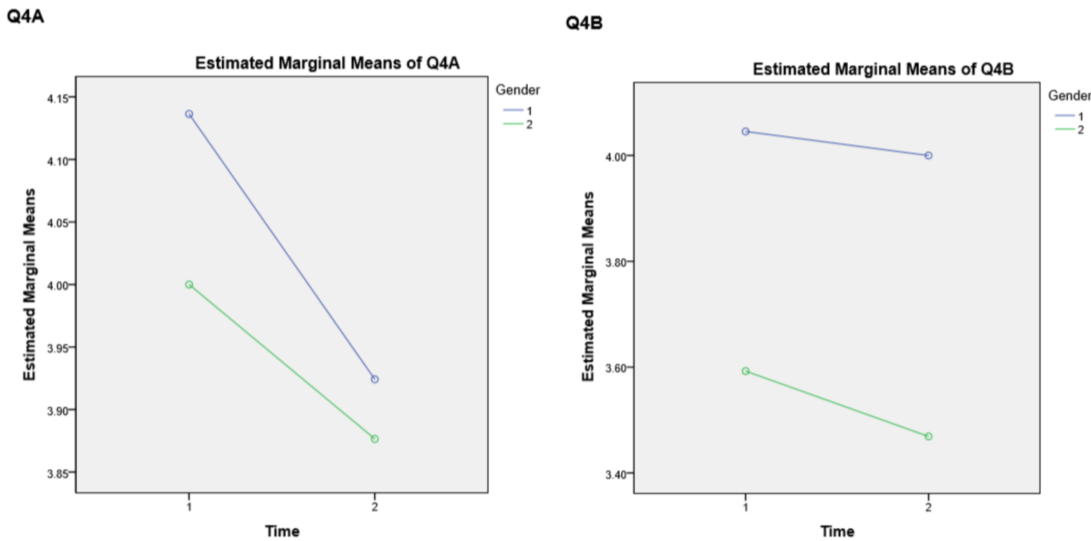

Figure 4. Comparative graph showing responses for both males and females for the pre- and post-survey for question 4.

Figure 4 shows that participants were less agreeable with positive statements and slightly less agreeable with negative statements. These trends demonstrate that students were less willing to agree that science's main purpose is the development of theories and they were also slightly less willing to agree that science's main purpose is the development of ideas.

Table 9. Univariate Tests for question 4.

Source	Measure	Type III Sum of Squares	Df	Mean Square	F	Sig.
Time	Q4A: Sphericity Assumed	.683	1	.683	2.925	.094
	Q4A: Greenhouse-Geisser	.683	1.000	.683	2.925	.094
	Q4A: Huynh-Feldt	.683	1.000	.683	2.925	.094
	Q4A: Lower-bound	.683	1.000	.683	2.925	.094
	Q4B: Sphericity Assumed	.173	1	.173	.645	.426
	Q4B: Greenhouse-Geisser	.173	1.000	.173	.645	.426
	Q4B: Huynh-Feldt	.173	1.000	.173	.645	.426
	Q4B: Lower-bound	.173	1.000	.173	.645	.426
Time* Gender	Q4A: Sphericity Assumed	.048	1	.048	.204	.653
	Q4A: Greenhouse-Geisser	.048	1.000	.048	.204	.653
	Q4A: Huynh-Feldt	.048	1.000	.048	.204	.653
	Q4A: Lower-bound	.048	1.000	.048	.204	.653
	Q4B: Sphericity Assumed	.037	1	.037	.138	.712
	Q4B: Greenhouse-Geisser	.037	1.000	.037	.138	.712
	Q4B: Huynh-Feldt	.037	1.000	.037	.138	.712
	Q4B: Lower-bound	.037	1.000	.037	.138	.712
Error (Time)	Q4A: Sphericity Assumed	10.966	47	.233		
	Q4A: Greenhouse-Geisser	10.966	47.000	.233		
	Q4A: Huynh-Feldt	10.966	47.000	.233		
	Q4A: Lower-bound	10.966	47.000	.233		
	Q4B: Sphericity Assumed	12.605	47.000	.268		
	Q4B: Greenhouse-Geisser	12.605	47.000	.268		
	Q4B: Huynh-Feldt	12.605	47.000	.268		
	Q4B: Lower-bound	12.605	47.000	.268		

Table 9 shows the results of the test for significance for both pre- and post-survey within subjects (males and females) and between subjects (comparing males and females). Set 4, positive statements, show that participant responses are approaching statistical significance (p=.094).

Statistics for Question 5: Questions deal with whether science should be shared with the public and the role of how important it is for the public to understand science:

Table 10. Descriptive Statistics for Set of Questions 5.

	Gender	Mean	Std. Deviation	N
Q5A_Pr	1	3.7576	.70660	22
	2	3.4938	.58741	27
	Total	3.6122	.65031	49
Q5A_Post	1	3.2121	.82002	22
	2	3.1481	.70002	27
	Total	3.1769	.74877	49
Q5B_Pr	1	1.9394	.71741	22
	2	1.6543	.58090	27
	Total	1.7823	.65458	49
Q5B_Post	1	1.7576	.56514	22
	2	1.6667	.55470	27
	Total	1.7075	.55541	49

Table 10 shows the mean responses for the Likert scale for both genders for a pre- and post-survey for question 5.

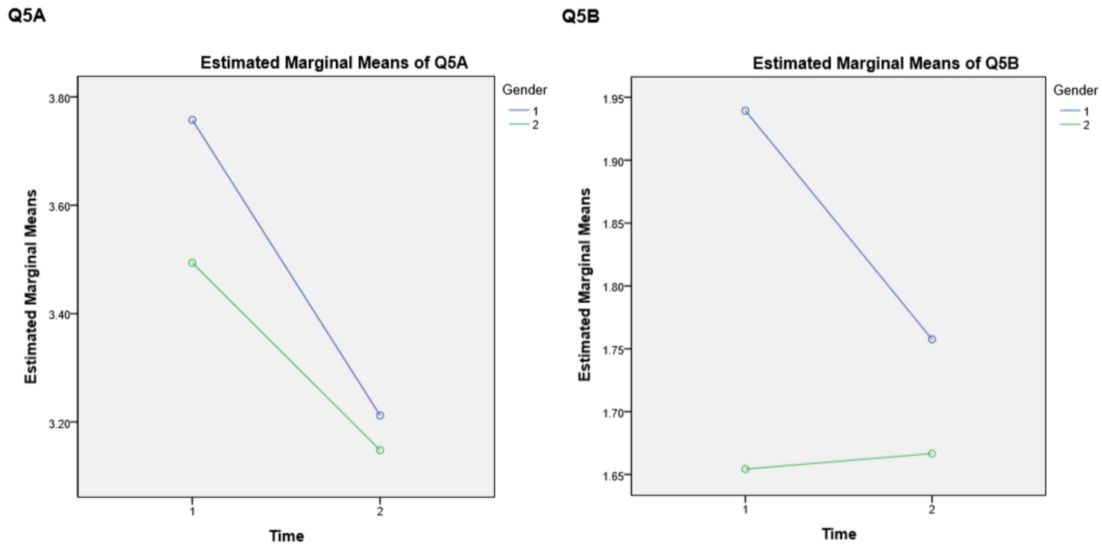

Figure 5 Comparative graph showing responses for both males and females for the pre- and post-survey for question 5.

Figure 5 shows that participants were less agreeable with positive statements and males were less agreeable with negative statements while females were slightly more agreeable. These trends demonstrate that students were less likely to agree with statements regarding the importance of the public knowing about scientific learning and the public understanding scientific work. Also, males were less likely to agree, while females were slightly more likely to agree, with statements saying the public does not need to know and that the public cannot understand science.

Table 11. Univariate Tests for question 5.

Source	Measure	Type III Sum of Squares	Df	Mean Square	F	Sig.
Time	Q5A: Sphericity Assumed	4.813	1	4.813	13.571	.001
	Q5A: Greenhouse-Geisser	4.813	1.000	4.813	13.571	.001
	Q5A: Huynh-Feldt	4.813	1.000	4.813	13.571	.001
	Q5A: Lower-bound	4.813	1.000	4.813	13.571	.001
	Q5B: Sphericity Assumed	.174	1	.174	.782	.381
	Q5B: Greenhouse-Geisser	.174	1.000	.174	.782	.381
	Q5B: Huynh-Feldt	.174	1.000	.174	.782	.381
	Q5B: Lower-bound	.174	1.000	.174	.782	.381
Time* Gender	Q5A: Sphericity Assumed	.242	1	.242	.682	.413
	Q5A: Greenhouse-Geisser	.242	1.000	.242	.682	.413
	Q5A: Huynh-Feldt	.242	1.000	.242	.682	.413
	Q5A: Lower-bound	.242	1.000	.242	.682	.413
	Q5B: Sphericity Assumed	.229	1	.229	1.026	.316
	Q5B: Greenhouse-Geisser	.229	1.000	.229	1.026	.316
	Q5B: Huynh-Feldt	.229	1.000	.229	1.026	.316
	Q5B: Lower-bound	.229	1.000	.229	1.026	.316
Error (Time)	Q5A: Sphericity Assumed	16.670	47	.355		
	Q5A: Greenhouse-Geisser	16.670	47.000	.355		
	Q5A: Huynh-Feldt	16.670	47.000	.355		
	Q5A: Lower-bound	16.670	47.000	.355		
	Q5B: Sphericity Assumed	10.468	47.000	.223		
	Q5B: Greenhouse-Geisser	10.468	47.000	.223		
	Q5B: Huynh-Feldt	10.468	47.000	.223		
	Q5B: Lower-bound	10.468	47.000	.223		

Table 11 shows the results of the test for significance for both pre- and post-survey within subjects (males and females) and between subjects (comparing males and females). Set 5, positive statements, show that participant responses are highly significant (p=.001).

Statistics for Question 6: Questions deal with working in the field of science and whether that would be a positive experience:

Table 12. Between-Subject Factors and Descriptive Statistics for Set of Questions 6.

	Gender	Mean	Std. Deviation	N
Q6A_Pr	1	3.8273	.80308	22
	2	3.4815	.77511	27
	Total	3.6367	.79862	49
Q6A_Post	1	3.6636	.86053	22
	2	3.4963	.72827	27
	Total	3.5714	.78634	49
Q6B_Pr	1	2.1455	.74625	22
	2	2.5481	.70948	27
	Total	2.3673	.74649	49
Q6B_Post	1	2.1182	.73461	22
	2	2.3333	.62512	27
	Total	2.2367	.67783	49

Table 10 shows the mean responses for the Likert scale for both genders for a pre- and post-survey for question 5.

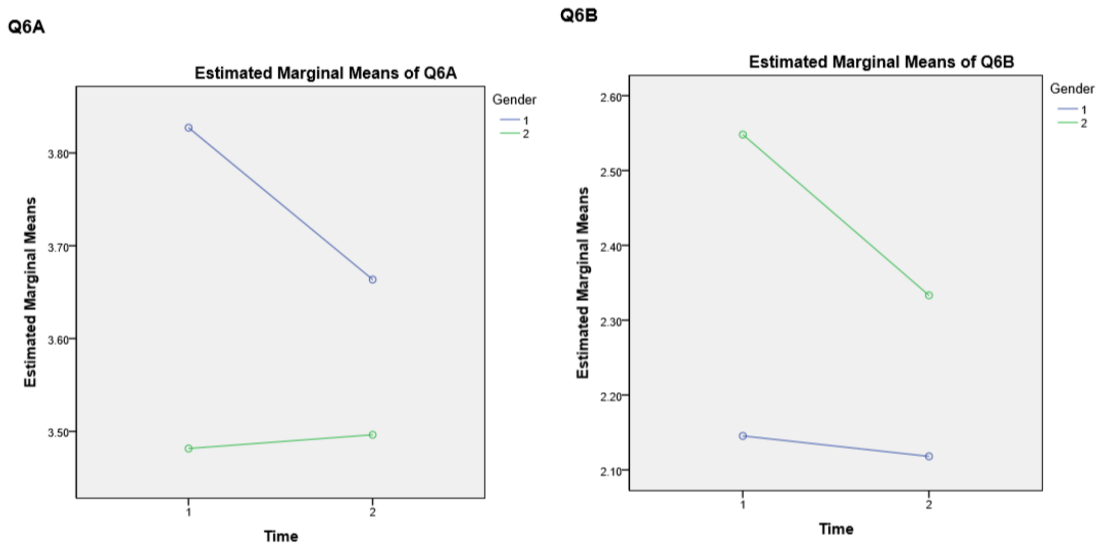

Figure 6. Comparative graph showing responses for both males and females for the pre- and post-survey for question 2.

Figure 6 shows that male participants were less agreeable with positive statements and females were slightly more agreeable while males were slightly less agreeable with negative statements and females were less agreeable with negative statements. These trends demonstrate that males were less likely to agree, while females were slightly more likely to agree, with statements that working in science would be a positive experience. Also, both males and females were less likely to agree with statements that working in science would be a negative experience.

Table 13. Univariate Tests for question 6.

Source	Measure	Type III Sum of Squares	Df	Mean Square	F	Sig.
Time	Q6A: Sphericity Assumed	.134	1	.134	.837	.365
	Q6A: Greenhouse-Geisser	.134	1.000	.134	.837	.365
	Q6A: Huynh-Feldt	.134	1.000	.134	.837	.365
	Q6A: Lower-bound	.134	1.000	.134	.837	.365
	Q6B: Sphericity Assumed	.355	1	.355	1.414	.240
	Q6B: Greenhouse-Geisser	.355	1.000	.355	1.414	.240
	Q6B: Huynh-Feldt	.355	1.000	.355	1.414	.240
	Q6B: Lower-bound	.355	1.000	.355	1.414	.240
Time* Gender	Q6A: Sphericity Assumed	.193	1	.193	1.203	.278
	Q6A: Greenhouse-Geisser	.193	1.000	.193	1.203	.278
	Q6A: Huynh-Feldt	.193	1.000	.193	1.203	.278
	Q6A: Lower-bound	.193	1.000	.193	1.203	.278
	Q6B: Sphericity Assumed	.213	1	.213	.848	.362
	Q6B: Greenhouse-Geisser	.213	1.000	.213	.848	.362
	Q6B: Huynh-Feldt	.213	1.000	.213	.848	.362
	Q6B: Lower-bound	.213	1.000	.213	.848	.362
Error (Time)	Q6A: Sphericity Assumed	7.542	47	.160		
	Q6A: Greenhouse-Geisser	7.542	47.000	.160		
	Q6A: Huynh-Feldt	7.542	47.000	.160		
	Q6A: Lower-bound	7.542	47.000	.160		
	Q6B: Sphericity Assumed	11.809	47.000	.251		
	Q6B: Greenhouse-Geisser	11.809	47.000	.251		
	Q6B: Huynh-Feldt	11.809	47.000	.251		
	Q6B: Lower-bound	11.809	47.000	.251		

Table 13 shows the results of the test for significance for both pre- and post-survey within subjects (males and females) and between subjects (comparing males and females). There is no statistical significance seen in this subset of questions (p=.365).

Qualitative Results

The journal responses showed two different themes: Enjoyment of hands-on activities and frustration with lack of direct instruction. Enjoyment of hands-on activities was the most prevalent theme noted. Students made specific mention of working in collaboration with their peers to complete various tasks. Additionally, limited note taking was a frequent reason noted for the enjoyment of hands-on activities. Conversely, frustration with lack of direction was the second most common theme noted. Students' journal responses frequently noted feelings of confusion and uncertainty with the lack of direction.

CHAPTER 5

DISCUSSION, RECOMMENDATIONS, & CONCLUSION

In this chapter the major findings of the paper are reviewed while connecting these findings to the literature. The limitations and suggestions for the direction of future research are followed by general conclusions.

Major Findings from Survey

Research Questions 1: Will students' attitudes towards science change following the completion of an IBL program?

The survey results revealed the students' attitudes towards science while using an IBL approach over the period of one school year. To evaluate the null hypothesis to show validity in the findings a quantitative research design using a Likert scale survey was implemented. Findings were compared between response times and between genders.

Findings from the survey

#1 Will students believe the purpose of science is for either testing theories or revealing truths following the IBL process?

The null hypothesis was supported ($p=.360$; $p > .05$). The findings showed that there was no significant difference between survey responses between science's purpose being either testing theories or revealing truths. There was a trend where students were more likely to agree with statements that supported the idea that one of science's purposes is to test theories. This would be exemplified during our hands-on projects where students were asked to complete a guided inquiry project. Research originally gathered by Boaler (1998) and presented by Bruder and Prescott (2013) showcased that students' content knowledge was on par with their peers from traditional educational practices, especially where traditional assessment is concerned, and that attitudes were more positive overall. This shows students who were testing theories through projects believe that the main reason behind science in general is to test theories. Almost equal number of participants were also likely to agree with statements that claimed science's main role was to reveal truths.

#2 Will students believe in science's ability to provide all answers to all questions be impacted following the IBL process?

The null hypothesis was supported (p=.274; p >.05). The survey questions dealing with science's ability to provide all answers to all questions showed there was no significant difference reported. A goal of inquiry is to provide students with a starting point to find the answers to their questions. However, many researchers have noted that IBL can lead to students feeling unsure of their learning and confused and that deeper learning can occur from a more guided approach to education (Hardiman, Pollatsek, and Well 1986; Brown and Campione 1994; Moreno 2004). In this study, there was a trend where males were more agreeable, and females were less agreeable with statements saying that science is limited in its ability to provide all responses; however, this was not statistically significant. Responses that claimed science can reveal all truths were neither less nor more agreeable for males and less agreeable for females over the same period.

#3 Will students have open minded beliefs and accept that science does not have all answers following the IBL process?

The null hypothesis was supported (p=.065; p>.05) Survey questions that discuss the topic of having an open mind to change pre-existing beliefs and the acceptance of not having an answer to all questions showed an approaching level of significance. Over time, the responses were less agreeable for both participants for openness to change and their acceptance of science not having all the answers. Additionally, responses were also less agreeable for statements pertaining to there being scientific truths and following other scientists' ideas without proper validation. Student attitudes toward science have remained unchanged when compared to the practicality and importance of science, however students demonstrate less satisfaction with the instructional methods of science in the education system (Potvin & Hasni, 2014).

#4 Will students believe that science's purpose is to generate ideas following the IBL process?

The null hypothesis was supported (p=.094; p>.05) The findings showed that responses to the statements whether science's purpose is to provide ideas or to develop technology approached significance. The responses were less agreeable for both participants regarding science being an idea generating endeavour. Responses were also less agreeable for statements that alluded to science being for the development of technology. This finding could be related to students not appreciating how broad science can be possibly because of the lack of direct instruction of the IBL method. Clark (1989), reviewed 70 studies involving self-guided teaching style and found that students with lower academic abilities did score lower on posttest versus pretest measures.

#5 Will students believe that science's purpose is to make others aware and that the public benefits from its understanding through the IBL process?

The null hypothesis was rejected for male students (p=.001; p>.05)

The findings showed that male respondents were less agreeable, over the course of the study, with statements dealing with the importance of society learning and understanding scientific findings. When reviewing females' responses, there was no statistical significance regarding responses concerning the importance of communicating scientific findings and the importance of society understanding these findings. Kind, Jones and Barby (2007), claimed students viewed science learned in classrooms versus science practiced in society as two different entities and that the different entities of school science such as a science teacher, learning environment and the content studied should be evaluated individually opposed to collectively.

#6 Will students believe working in the field of science would be interesting and rewarding following the IBL process?

The null hypothesis was supported (p=.365; p>.05). Survey questions that discuss the topic of working in science as a positive experience and conversely that working in science would be unenjoyable were shown to not be significant. The responses were less agreeable for male participants regarding having a positive outlook on a career in science and slightly more agreeable for females, but less agreeable for both participants concerning science not being an enjoyable profession. It is difficult to evaluate students' desires to practice in any field of science as students' attitudes toward science in the classroom or the real world greatly differ (Ramsden, 1998).

Major Findings from Journal Data

Research Question 2: How will IBL strategies impact the student's enjoyment or satisfaction in science?

Student enjoyment or satisfaction in science is presented in two different themes. The first theme shows that students enjoyed the hands-on aspect of the IBL approach for teaching science. This could be a result of the freedom that is granted students in completing hands-on activities. This is showcased when the following was said by a student, “My favourite part of science class is experiments and hands-on projects because they help us learn in a fun way and is really fasinating [sic].” Also, another positive for students may be the lack of note-taking and overall structure that is traditional in many other classes. The above is supported by the following student comment, “I enjoy studying science since it’s interesting and we are always doing experiments instead of always writing notes or sitting in one place.”

The second theme showed that students did not have greater enjoyment or satisfaction with science because they did not enjoy the lack of structure. One student commented, “My least favourite part of science class is that sometimes I feel like the lessons are unorganized and that not enough instruction is given.” Furthermore, they specifically mentioned feeling frustrated and uncertain because they were not receiving direct instruction on what they were supposed to learn. An example of direct instruction would be providing students with a worksheet to practice and develop a certain skill. Nadolski, Kirschner and Van Merriënboer (2005) found that law students who used worksheets for their learning outperformed their peers who used a discovery method for the same task. Students should be provided with the necessary information as per the curriculum to feel comfortable and secure with their learning and then use those skills to solve inquiry type problems. Students should be provided with the necessary information and then be allowed to explore the appropriate and affective use of this knowledge.

Research Question 3: How will IBL strategies impact student achievement?

Inquiry Based Learning’s impact on student achievement is varied. When looking at achievement, for assessment based on the science curriculum there were no observable changes over the period of the study. The changes however may not come until later as the effort put into developing critical thinking through the IBL process is not necessary for short term gain but more so for a lifetime of learning (Bruner, 1961). Winter (1989) and Artigue and Blomhøj (2013) describe the purpose of the IBL process as developing motivation to learn and transferable skills for later obstacles and challenges that students will incur in their lives'.

Research Question 4: Will students prefer the IBL method compared to a more teacher centered approach?

There were differing opinions regarding the IBL approach for science instruction. As mentioned above most of the students gravitated towards IBL instruction because of the hands-on aspect brought to light in the journal entries. Hattie (2008) discussed IBL and explained that the instruction method might be beneficial for students when they have the critical thinking skills but have not been challenged to approach learning opportunities in that manner. He went on to say that IBL has been shown to improve critical thinking ability, academic performance and advance students' attitudes toward science. The opposite side to this is the students who felt that a more teacher-centered approach with direct teaching would be more beneficial for them and their learning. These students felt as though they were not "learning" and were constantly working on tasks without the ability or instruction to consolidate what they learned. Sweller et al. (1982), discussed how the working memory when looking for solutions to issues cannot be used to store information into the long-term memory. Lastly, having students simply searching for solutions to problems is not going to lead to the development of long-term memories therefore the IBL process is not conducive to learning new skills.

Limitations of the Study

The sample size of 49 students limited the ability to get the most complete picture possible as that is only slightly over half of the 80 students eligible for the survey. Due to the incomplete data sets of some students, the results do not represent the entire population. Several survey and journal responses were not completed because of student absences and therefore they were left out of the study. Another limitation of the study is the lack of consistency with inquiry methods throughout the course. The program was designed to consistently use an inquiry method but due to student confusion at times other teaching methods were utilized to ensure the curriculum was appropriately delivered. The inquiry method continued to be the primary source of instruction throughout the entire year. Another limitation of the study was the lack of control group due to the potential benefit IBL could have on one group therefore not providing IBL to all students could be deemed unethical. Comparing student success by looking at their grade levels from the current year compared to the previous year was made difficult by the fact students in the study had several different teachers with different teaching styles as well as a different curriculum. Therefore, comparing academic performance between the year prior to IBL instruction and the year of IBL instruction was not a reasonable option. Furthermore, science attitudinal scales are also questioned for their ability to measure what they purport to measure. Osborne et al. (2003) looked at what is really being measured when we look at students' attitudes towards science. Therefore, it is difficult to say whether we are measuring the students' attitudes towards science, the instruction method, the instructor, or something else. Still this survey method is one of the only options available to researchers in this field.

Conclusion

Based on the statistical analysis and interpretations of the data collected as well as journal entries' assessment, we can say that IBL has little to no effect on student enjoyment and satisfaction in science and is not statistically significant on positively impacting students' achievement either through positive response or improved academic performance. More specifically, when assessing the qualitative evidence in the form of student journal entries, it appears that IBL was well received by students who were not motivated in traditional methods such as the teacher directed classroom. This can be explained by students' desire to have different learning styles met and avoid unpleasant and passive aspects of learning in the form of note taking. The other conclusion that can be drawn is that students did not enjoy the lack of direct instruction. Students are habituated on routine and direct instruction and therefore could feel "unsafe" taking risks with inquiry learning. Comparatively, some students found the hands-on approach of IBL challenging due to the indirect instruction. Students believed they were left to learn many concepts on their own through trial and error. This is difficult for students at times and, therefore, left them frustrated with the IBL model.

When assessing the quantitative research, generally there is no statistical difference that IBL has on positively impacting students' achievement either through positive response or improved academic performance. One aspect of the student survey did show statistical significance in that males did not see the public understanding of science as important comparatively to females, however this is not seen as an important discovery specifically since it does not tie directly into classroom teaching styles or learning but rather a specific opinion on science.

Additionally, the results also showed approaching significance for the concept of the main purpose of science being either to develop theories or ideas. Students responded more negatively over time to the idea that science's main role is to develop theories. This means students did not view science as a vehicle to develop theories to help us better understand what happens around us. Also, approaching statistical significance are statements dealing with being open to changing one's viewpoint regarding truths. This means students responded more negatively towards statements that deal with changing one's openness to changing viewpoints of certain scientific truths. No other statistically significant statistics were found from the survey.

Moving forward, it appears a balance of teacher directed, and student directed approach of IBL to be most effective when measuring student motivation, engagement and attitude in science.

Further Studies

Further studies that would provide more insight into this area should focus on the development of the IBL style that provides the proper amount of guidance and structure that can support students while they learn through open inquiry. A study that looks at a specific target audience, for example a single gendered population or those with identified learning preferences could provide greater insight into the best suited populations for future studies of IBL instruction.

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APPENDICES

Appendix A

WHAT IS YOUR ATTITUDE TOWARD SCIENCE?

(A Scientific Attitude Inventory)

SAI II

There are some statements about science on the next two pages. Some statements are about the nature of science. Some are about how scientists work. Some of these statements describe how you might feel about science. You may agree with some of the statements and you may disagree with others. That is exactly what you are asked to do. By doing this, you will show your attitudes toward science.

After you have carefully read a statement, decide whether or not you agree with it. If you agree, decide whether you agree mildly or strongly. If you disagree, decide whether you disagree mildly or strongly. You may decide that you are uncertain or cannot decide. Then, find the number of that statement on the answer sheet, and blacken the:

Ⓐ **if you agree strongly**

Ⓑ **if you agree mildly**

Ⓒ **if you are uncertain or cannot decide**

Ⓓ **if you disagree mildly**

Ⓔ **if you disagree strongly**

EXAMPLE:

I would like to have a lot of money.

Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

The person who marked this example agrees strongly with the statement, "I would like to have a lot of money."

Please respond to each statement and blacken only ONE space for each statement.

1. I would enjoy studying science.
2. Anything we need to know can be found out through science.
3. It is useless to listen to a new idea unless everybody agrees with it.
4. Scientists are always interested in better explanations of things.
5. If one scientist says an idea is true, all other scientists will believe it.
6. Only highly trained scientists can understand science.
7. We can always get answers to our questions by asking a scientist.
8. Most people are not able to understand science.
9. Electronics are examples of the really valuable products of science.
10. Scientists cannot always find the answers to their questions.
11. When scientists have a good explanation, they do not try to make it better.
12. Most people can understand science.
13. The search for scientific knowledge would be boring.
14. Scientific work would be too hard for me.
15. Scientists discover laws which tell us exactly what is going on in nature.
16. Scientific ideas can be changed.
17. Scientific questions are answered by observing things.
18. Good scientists are willing to change their ideas.
19. Some questions cannot be answered by science.
20. A scientist must have a good imagination to create new ideas.
21. Ideas are the most important result of science.

22. I do not want to be a scientist.

23. People must understand science because it affects their lives.

24. A major purpose of science is to produce new drugs and save lives.

25. Scientists must report exactly what they observe.

26. If a scientist cannot answer a question, another scientist can.

27. I would like to work with other scientists to solve scientific problems.

28. Science tries to explain how things happen.

29. Every citizen should understand science.

30. I may not make great discoveries, but working in science would be fun.

31. A major purpose of science is to help people live better.

32. Scientists should not criticize each other's work.

33. The senses are one of the most important tools a scientist has.

34. Scientists believe that nothing is known to be true for sure.

35. Scientific laws have been proven beyond all possible doubt.

36. I would like to be a scientist.

37. Scientists do not have enough time for their families or for fun.

38. Scientific work is useful only to scientists.

39. Scientists have to study too much.

40. Working in a science laboratory would be fun

Appendix B

POSITION STATEMENTS AND

ATTITUDE STATEMENTS OF THE

SCIENTIFIC ATTITUDE INVENTORY II

These are the position statements and corresponding attitude statements of the *Scientific Attitude Inventory II*.

The position statements are labeled with a number and a letter, for example, 1-A. The letter designates whether the position statement is positive (A) or negative (B). The position statements are in pairs where the pair 1-A and 1-B are intended to be opposite positions regarding the same point of view.

The numbers in front of each attitude statement indicates its number in the SAI II.

1-A The laws and/or theories of science are approximations of truth and are subject to change.

4. Scientists are always interested in better explanations of things.
16. Scientific ideas can be changed.
34. Scientists believe that nothing is known to be true for sure.

1-B The laws and/or theories of science represent unchangeable truths discovered through science.

11. When scientists have a good explanation, they do not try to make it better.
15. Scientists discover laws which tell us exactly what is going on in nature.
35. Scientific laws have been proven beyond all possible doubt.

2-A Observation of natural phenomena and experimentation is the basis of scientific explanation. Science is limited in that it can only answer questions about natural phenomena and sometimes it is not able to do that.

10. Scientists cannot always find the answers to their questions.
19. Some questions cannot be answered by science.
33. The senses are one of the most important tools a scientist has.

2-B The basis of scientific explanation is in authority. Science deals with all problems and it can provide correct answers to all questions.

2. Anything we need to know can be found out through science.
7. We can always get answers to our questions by asking a scientist.
26. If a scientist cannot answer a question, another scientist can.

3-A To operate in a scientific manner, one must display such traits as intellectual honesty, dependence upon objective observation of natural events, and willingness to alter one's position on the basis of sufficient evidence.

17. Scientific questions are answered by observing things.
18. Good scientists are willing to change their ideas.
25. Scientists must report exactly what they observe.

3-B To operate in a scientific manner one needs to know what other scientists think; one needs to know all the scientific truths and to be able to take the side of other scientists.

3. It is useless to listen to a new idea unless everybody agrees with it.
5. If one scientist says an idea is true, all other scientists will believe it.
32. Scientists should not criticize each other's work.

4-A Science is an idea-generating activity. It is devoted to providing explanations of natural phenomena. Its value lies in its theoretical aspects.

20. A scientist must have a good imagination to create new ideas.
21. Ideas are the most important result of science.
28. Science tries to explain how things happen.

4-B Science is a technology-developing activity. It is devoted to serving mankind. Its value lies in its practical uses.

9. Electronics are examples of the really valuable products of science.
24. A major purpose of science is to produce new drugs and save lives.
31. A major purpose of science is to help people live better.

5-A Progress in science requires public support in this age of science, therefore, the public should be made aware of the nature of science and what it attempts to do. The public can understand science and it ultimately benefits from scientific work.

12. Most people can understand science.
23. People must understand science because it affects their lives.
29. Every citizen should understand science.

5-B Public understanding of science would contribute nothing to the advancement of science or to human welfare, therefore, the public has no need to understand the nature of science. They cannot understand it and it does not affect them.

6. Only highly trained scientists can understand science.
8. Most people are not able to understand science.
38. Scientific work is useful only to scientists.

6-A Being a scientist or working in a job requiring scientific knowledge and thinking would be a very interesting and rewarding life's work. I would like to do scientific work.

1. I would enjoy studying science.
27. I would like to work with other scientists to solve scientific problems.
30. I may not make great discoveries, but working in science would be fun.
36. I would like to be a scientist.
40. Working in a science laboratory would be fun.

6-B Being a scientist or working in a job requiring scientific knowledge and thinking would be dull and uninteresting; it is only for highly intelligent people who are willing to spend most of their time at work. I would not like to do scientific work.

13. The search for scientific knowledge would be boring.
14. Scientific work would be too hard for me.
22. I do not want to be a scientist.
37. Scientists do not have enough time for their families or for fun.
39. Scientists have to study too much.

Appendix C

Student Voices

As part of the study students were asked to answer statements in regard to how they felt about the science program offered to them and science in general. There were two themes that arose from the journal data: 1) hands-on activities; 2) lack of direct instruction. These themes provide further information into the students' attitudes towards science in addition to the survey. The following are examples of students' comments from the journal portion of the study.

"My favourite part of science is doing hands-on projects because I get to think logically and learn in a different way." Tatiana

"I enjoy studying science since it's interesting and we are always doing experiments instead of always writing notes or sitting in one place." Ashley

"My favourite part of science class is experiments and hands on projects because they help us learn in a fun way and is really fasinating [sic]." Sylvester

"My favourite part of science is the hands on and the projects, [sic] so we arent [sic] just sitting down all day." Colton

'...is doing hands-on projects. I like this because you can do/make/use your own ideas towards your project." Austin

"I enjoy science because I get to build stuff and learn new things." Jaspreet

"My favorite part of science class is doing expirements [sic] because then I make observations and apply my knowledge to real life." Sohil

"My favourite part of science class is Hands-on because I like trying and it myself." Anonymous

"I enjoy studying science because there are multiple different things you can learn but the difference from other classes is your [sic] able to learn both research and hands-on and discover your interests ." Nya

"My favorite part of science class is the hands-on and how we do a bit of researching with our research project. I like the hands on because it helps me learn but I also like the research because what I learn while researching I can try to incorperat [sic] into hands-on." Hailey

"My favorite part of science is when we do hands on projects because I feel more interested when i'm [sic] the one doing or making things. I'm more engaged when we do hands on things." Jacob

The second theme is the lack of direct instruction which led to student frustration and not understanding. The following quotes discuss their feelings towards IBL:

“...I’m sorry but my least favourite part of science is the fact that we don’t get any lessons on the subjects we learn. We just get told what pages in the textbook to read. I don’t learn from just reading...I read about it and I’m still confused. I want proper lessons that actually teach me about the stuff we learn.” Shannon

“My least favourite part of science class is that sometimes I feel like the lessons are unorganized and that not enough instruction is given.” Matteo

“My least favourite part of science is how unorganized it is. It feels like we are always doing projects with ourself [sic] and never actually reading the book and having an in class lesson. I wish it had more structure so we could learn all of the curriculum, not just what the class presents.” Madelyn

“My least favourite part of science class is having to learn the lessons myself rather than the teacher teaching us them because when a teacher does it I will know exactly what is on the test, it also helps me be more engaged in the learning.” Ali

Appendix D

CONSENT TO PARTICIPATE IN RESEARCH

Title of Study: **Inquiry Based Learning in Science**

You are asked to participate in a research study conducted by Dan Frezell and Dr. Geraldine Salinitri from the **Faculty of Education** at the University of Windsor**.**

If you have any questions or concerns about the research, please feel to contact **Dan Frezell at frezell@uwindsor.ca, or Dr. Geraldine Salinitri at 519-253-3000 ext: 3961 or sgeri@uwindsor.ca**

PURPOSE OF THE STUDY

Inquiry based learning is something that I am very enthusiastic about and hope to learn more about the impact it has on education. The purpose I have for completing this study is to see the impact inquiry based learning has on students' attitudes towards science.

PROCEDURES

If you volunteer to participate in this study, you will be asked to:

Complete two surveys, one at the beginning of the school year and the other at the conclusion of the school. You will also be asked to complete journal entries describing your experiences in the study up until that time. This will happen periodically throughout the duration of the study. The timeline of the study will run from approximately September 2015, until June 2016. The entirety of the study will take place within the regular classroom setting during regular class hours. Results of the study will be provided following the conclusion.

[*Specify the participant's assignment to study groups, length of time for participation in each procedure, the total length of time for participation, frequency of procedures, location of the procedures to be done, etc. Provide details about any plan to contact participants for follow-up sessions or subsequent related study.*]

POTENTIAL RISKS AND DISCOMFORTS

The potential for risk and discomfort is minimal. If students feel uncomfortable at any point of the study then they are able to withdraw without any consequence.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

Students will have the opportunity to participate in a post-secondary study and learn about the field of research. Furthermore, students will be presented the opportunity to develop their academic skills through the use of inquiry based learning. The hope is that this style of learning will provide students with greater motivation and excitement for all future learning.

As for the field of teaching there is the potential for greater understanding of how to motivate students and what type of teaching strategies lead to positive outcomes for students. Greater support for teaching students to ask questions and be inquisitive minded and less concern with fact based education.

COMPENSATION FOR PARTICIPATION

There is no formal compensation planned at this time. There may be some sort of informal compensation provided to students following the completion of the study.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission.

The information will be secured at my place of residence and will only be shared with my advisor. The completed surveys and journal entries will be kept at my home in my office for confidentiality purposes. The results from the survey will be kept on my computer—which is password protected—using a web based application that requires a password. No names will be used in the data analysis and research findings.

PARTICIPATION AND WITHDRAWAL

The participant may remove themselves from the study at any time by simply notifying the researcher. If the participant does decide to withdraw their information will be destroyed and there will be no consequence. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

FEEDBACK OF THE RESULTS OF THIS STUDY TO THE PARTICIPANTS

The results will be discussed with the students following the completion of the study.

Web address: ____

Date when results are available: __________________________________

SUBSEQUENT USE OF DATA

These data may be used in subsequent studies, in publications and in presentations.

RIGHTS OF RESEARCH PARTICIPANTS

If you have questions regarding your rights as a research participant, contact: Research Ethics Coordinator, University of Windsor, Windsor, Ontario, N9B 3P4; Telephone: 519-253-3000, ext. 3948; e-mail: ethics@uwindsor.ca

SIGNATURE OF RESEARCH PARTICIPANT/LEGAL REPRESENTATIVE

I understand the information provided for the study: **Inquiry Based Learning in Science,** as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

______________________________ ______________________

Name of Participant Date

SIGNATURE OF INVESTIGATOR

These are the terms under which I will conduct research.

____

Name of Investigator

VITA AUCTORIS

NAME:	Dan Frezell
PLACE OF BIRTH:	Windsor, ON
YEAR OF BIRTH:	1984
EDUCATION:	Bachelor of Arts Honours, 2007 University of Windsor
	Bachelor of Education, 2010 University of Windsor