Elementary Teachers’ Beliefs about and Implementation of Inquiry-Based Science Teaching

By

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Abstract

The National Science Education Standards (NSES) (NRC, 1996) encourages teachers to implement inquiry-based science teaching in their classrooms. It has been stressed that teachers are responsible for implementing scientific inquiry in classrooms. However, studies indicate that teachers form individualized perspectives of inquiry, and implement their understanding of science teaching in ways that may not match the perspectives of university researchers (Seung, 2014; Kang et al., 2008; Crawford, 2000; Keys, 2002). Although some teachers believe that they use inquiry-based teaching in their classroom, the authenticity of their inquiry teaching still needs to be examined through their concept of inquiry and their method of implementation. This qualitative study explores the concept of inquiry and its implementations as understood by elementary teachers, as taught through their science lessons. Three elementary classroom teachers from different backgrounds were interviewed regarding their beliefs about, and how they implement inquiry-based science teaching. The findings of this research indicates that while many teachers see inquiry-based science teaching as hands-on activities and doing experiments, teachers who received training in inquiry-based teaching workshops see inquiry-based teaching as a knowledge building process. While many teachers believe the purpose of inquiry-based teaching is about motivating students, teachers who have received professional scientific inquiry training focus more on teaching the content of science.

**Key Words:** inquiry-based science teaching, teachers’ beliefs, implement inquiry-based science lesson
Acknowledgements

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Chapter 1: INTRODUCTION

Introduction to the Research Study

The National Science Education Standards (NESE) (NRC, 1996) encourages teachers to implement inquiry-based science teaching in their classrooms. Inquiry-based science teaching, also known as authentic science teaching, emphasizes the ability of students to question, solve and understand scientific concepts (Morrison, 2013; NRC, 1996). Researchers see inquiry as an interaction between learners and teachers through scientific data and questions in order to cultivate the students’ understandings of science (Loretta, 2010). The NSES contains some specific teaching examples of what inquiry teaching looks like, but the precise definition of inquiry teaching still seems vague to teachers and researchers. Therefore, although it has been stressed that teachers have a responsibility to implement scientific inquiry in classrooms, studies indicate that teachers form individualized perspectives of inquiry and implement their understanding of science teaching in ways that may not match the perspectives of university researchers (Seung, 2014; Kang et al., 2008; Crawford, 2000; Keys, 2002).

The interpretations of inquiry have changed rapidly during the 20th Century, and because of the multiple meanings of scientific inquiry, the confusion amongst K-12 teachers of science have increased (Barrow, 2006). Researchers have revealed that the problem with our current science teaching is that it is an experimental study, which does not reflect the essence of scientific inquiry as a whole (Lederman, Lederman, & Antink, 2013). Consequently, a very narrow and distorted view of scientific inquiry is promoted in K-12 teachers (Lederman, Lederman, & Antink, 2013). Teachers generally promote the idea that inquiry is “finding things out” (Morrison, 2013, p. 578), and their knowledge
about inquiry-based science teaching directly impacts their implementation of the approach (Seung, 2014; Kang et al., 2008; Crawford, 2000). Although some teachers believe that they use inquiry-based teaching in their classroom, the legitimacy of their inquiry teaching still needs to be examined through their understanding of the concept of inquiry and method of implementing it. This study explores the concept of inquiry and its implementations as understood by elementary teachers, as taught through their science lessons.

**Purpose of the Study**

Although there is an increasing trend of studies based on teachers’ beliefs of inquiry, the focus is still on junior and high school teachers rather than elementary school teachers. In order to help elementary school teachers change some of their simplistic understandings and the way they teach inquiry-based science lessons, it is important to understand how they perceive science and inquiry, and the approach they use to implement this type of teaching. Moreover, the gap between the understanding of teachers and researchers can be identified and discussed through comparison. Therefore, this study will explore the beliefs of 3 teachers about inquiry-based science teaching and critically examine one ‘inquiry-based’ lesson from each teacher. It will investigate how elementary teachers incorporate inquiry-based strategies into their teaching, and also identify the gap between the teachers’ beliefs and their inquiry-based teaching practices.

**Research Topic and Questions**

This exploratory qualitative research study will be guided by the following questions:

1. What are the general beliefs of elementary teachers about inquiry-based science
2. How do elementary teachers implement inquiry-based science teaching in their classrooms?

Two sub-questions that will be examined are: What do teachers define as inquiry-based teaching, and what are teachers’ perspectives about an inquiry-based lesson?

Background of the Researcher

Chengcheng had been studying in China for 20 years, and the laboratory teaching method was the main teaching approach in science classroom from elementary school to university. When she was a student, the laboratory course was very structured. The four steps in the process of a typical science laboratory class were 1) the teacher demonstrated the experiment, 2) the students conducted the experiment step by step according to the laboratory manual book or teacher's guidance, 3) the students recorded the findings and data, and 4) the students finished an experiment report. The experiment report included six parts: the experiment materials, purpose, experiment process, result/data, conclusion, and further thoughts. This report was the main assessment tool for students’ learning. She discovered that the outcome of the laboratory teaching method is severely limited by the pursuit of accurate results from experiments. She found that students frequently faked the experiment results or copied each other’s experiment reports in order to get higher marks.

When she became a science teacher in China, China was experiencing a Science Curriculum Reform, and a new science curriculum was implemented. Inquiry-based science teaching was given a significant emphasis in that curriculum. The content of inquiry-based teaching in the curriculum was basically copied from The National Science Education Standards (NSES), and it did not have specific instructions for teachers to implement inquiry-based science teaching in classrooms. As a former science teacher, she
had a difficult time interpreting and comprehending the meaning of scientific inquiry. When she began her studies in OISE, she found that inquiry-based learning and teaching is widely used and introduced in not only science, but also math and other courses. She learnt a variety of methods to prepare inquiry-based lessons, but she still had some uncertainties about the meaning of scientific inquiry and how to implement inquiry-based lessons. Therefore, she paid extra attention on learning how to teach inquiry-based lessons. However, she found that different teachers have different understandings of scientific inquiry. Some of them believe that they are teaching inquiry-based lessons, but students still follow certain steps to do experiments, fill out worksheets, and remember scientific terms and facts.

Because of these reasons, she felt more curious about how classroom teachers perceived scientific inquiry and how they implemented it in their classrooms. Most importantly, she understood the importance of figuring out the gap between teachers’ perspectives and researchers’ interprets towards scientific inquiry. As a future teacher, she believed that inquiry-based teaching is the fundamental way of inspiring students to learn and of promoting authentic learning. She hypothesized that the traditional laboratory teaching method stifles the students’ motivation to learn and limits their learning capacity. In order to profoundly understand the definition and implementation of scientific inquiry, she analyzed the typical understandings of classroom teachers and their methods of implementations and compared them to research data. In this way, she acquired a thorough and comprehensive understanding about the concept and integrated it into her own teaching style.

**Overview**

The rationale behind this study is to develop an understanding about the beliefs of
teachers in connection to their approach to the implementation of inquiry-based science lessons. Chapter 2 presents a review of current related literature pertaining to typical teachers’ beliefs regarding inquiry-based science teaching from three themes: the definition and features of inquiry-based teaching, the beliefs of teachers about inquiry-based teaching, and key elements of how teachers implemented these beliefs. Chapter 3 describes the methodology and procedure used in this study, including information about the sample participants and data collection instruments. Chapter 4 identifies the participants in the study and describes the data as it addresses the research question. Chapter 5 includes limitations of the study, conclusions, recommendations for practice, and further reading and study. References and a list of appendix follow at the end.
Chapter 2: LITERATURE REVIEW

Researchers believe that scientific inquiry and teaching strategies should be discussed through three main domains, including the essential features of, the understanding of, and the practical implementation of scientific inquiry in the classroom (Lotter et al., 2007; Bybee, 2004; Kang et al., 2008). Therefore, three themes related to scientific inquiry and its teaching strategies have been discussed in this literature review: what inquiry-based teaching is, what teachers believe inquiry-based learning is, and what important elements for a teacher when they incorporate inquiry-based practices into a science lesson are.

What is inquiry-based learning?

Definition:

The National Science Education Standards (NSES) demonstrates the significant role of scientific inquiry in science education. In the revised version of NSES (2000), the definition of inquiry is provided:

Inquiry is agreed upon as student centered or open when students generate a question and carry out an investigation, teacher guided when the teacher selects the question and both students and teacher decide how to design and carry out an investigation (National Research Council, 2000).

The NSES requires elementary and secondary students to develop the ability to conduct and understand inquiry in science classrooms (NRC, 1996, P. 121). By analyzing the definition provided by NSES, Bybee sees the inquiry-based learning experience as a process that shape and modify students’ scientific knowledge, the scientific practice and the ways of scientific thinking (2011). However, Asay and Orgil conclude that inquiry is not only a learning or participating process, but also a media for learning canonical science knowledge (2010). Moreover, inquiry also refers to learning experiences that
contribute to gaining scientific knowledge and understanding the nature of science (Asay & Orgil, 2010).

A number of researchers make it clear that inquiry is not simply a hands-on learning experience, an experiment that confirms what has been taught, or a set of skills to be practiced (Asay & Orgil, 2010; Crawford, 2000; Huber & Moore, 2001; Trumbull et al., 2005). Inquiry-based learning should be a type of learning in which learners interact with scientific questions and data under the guidance of teachers to build on scientific understanding. Moreover, Lederman et al. see scientific inquiry as a systematic approach which integrates traditional scientific processes with scientific content, rationale and critical thinking to develop scientific understanding (2013). In their research, the Scientific Method is generally mistaken as an approach of inquiry-based science teaching. This method is interpreted as several established steps that all scientists obey to solve scientific problems. Researchers have made it clear that scientific inquiry should not include any steps to follow in sequence, but instead has a question generally lead the approach, which allow the approaches to differ broadly within a scientific domain (Lederman, Lederman, & Antink, 2013).

Features

The NSES provides the five key features of inquiry which represent both the roles of the teachers and the students in a science classroom. Bybee summarizes teachers’ roles in assisting inquiry-based learning according to the five essential features. These roles include: helping students ask or restate questions that lead them to investigate, gather, and interpret data to answer their questions, helping students understand the importance of accurate observations, helping students make connections between evidence and observations, helping them to organize scientific argumentation, and
introducing scientific features to students (2011). In Bybee’s former research, he summarized that learners should engage in a scientific-oriented question, use evidence to respond to the question, make connections between explanations and scientific knowledge, and communicate as well as justify explanations (2006).

Researchers also suggest that teachers develop the sense of self-direction that students possess by providing a continuum, which indicates more to less teacher directions and less to more learner directions (Seung et al., 2014; Morrison, 2013; Bybee, 2011). This continuum offers a standard of evaluating the inquiry level of the exemplary case study lessons in this research. Bybee gives a specific and detailed example of activities that are fully inquiry-based according to the five essential features. The activities should engage students in developing inquiry-based questions that build on their past understanding and knowledge, involve students in designing and improving their methods of investigation and have students report in different ways based on their results (Bybee, 2011).

Bybee also stresses that the primary purpose of doing inquiry-based teaching is not only developing scientific practices, but also scientific literacy and numeracy. He concludes that inquiry is the foundation of science education in elementary school (2011). Slavin et al. evaluate a variety of studies on inquiry-based teaching approach programs, and it is interesting to see that inquiry-based programs show more positive outcomes than those programs that used science kits in the Science Achievement Measure (2014). In Şimşek and Kabapınar’s study, by analyzing pre-tests and after-tests, they discovered that inquiry-based teaching contributes to the understanding that students have about scientific concepts (2010). It is also evident that the measurement skills, correlation/classification skills and hypothesizing skills of students have been greatly
improved (Şimşek & Kabapınar, 2010). These studies provide strong evidence for the benefits of using inquiry-based teaching in elementary school and reveal the significant role that it played in science education. Studies specify that further research directions should be focused on how teachers implement inquiry-based teaching strategies.

What do teachers believe is inquiry-based learning?

The lack of an agreed-upon conception of science inquiry

Although the NSES provides the definition and specific examples of giving scientific inquiry instructions in the classroom, researchers have different perspectives towards using the term ‘scientific inquiry’. Researchers such as Morrison (2013) and Barrow (2006) argue that the definition is not precise and operational, and that the NSES has no specific instructions for teachers to teach inquiry-based lessons in the classroom. This situation brings more confusion to teachers who are trying to practise teaching inquiry-based lessons. Therefore, more questions have been raised around the topic of the different understanding of scientific inquiry between teachers and researchers (Anderson, 2002). The interpretation of inquiry has changed rapidly during the late 20th Century. Barrow (2006) discussed that because of the multiple meanings of scientific inquiry, the confusion among K-12 teachers of science has been augmented. Various understandings and perceptions of scientific inquiry can be expected from the readers of the NSES.

Although inquiry is seen as the central core of science teaching after the NSES, some teachers still possess a simplistic concept of it (Blanchard, Southerland, & Granger, 2008). Asay and Orgill critically review articles of inquiry features published in The Science Teacher from 1998 to 2007. They analyze studies that illustrate the misuse of inquiry terminology by teachers (Asay & Orgill, 2010). The most common misuses of the term include: seeing inquiry-based teaching as discovery teaching, hands-on learning,
(Crawford, 2000) and asking authentic problems (Kang & Wallace, 2005). Moreover, it is evident that teachers’ personal beliefs about teaching and science influence their approach to teaching inquiry-based science (Morrison, 2013; Crawford, 2007; Anderson, 2002; Keys, 2001). Research demonstrates that conceptions and understandings about inquiry-based teaching of teachers determine their implementation levels of inquiry-based instruction (Seung, 2014; Rop, 2002; van Driel et al., 2001). However, research about teachers’ perceptions towards the purpose of inquiry, the process of carrying inquiry-based learning out and their motivation of implementing scientific inquiry is still limited.

**Teachers’ beliefs of inquiry**

The last 4 years saw an increasing trend of research on teachers’ conceptions of inquiry, however, researchers put emphasis on junior and high school level rather than primary level. Researchers discuss teachers’ conceptions from different perspectives through investigation and examination. Asay and Orgill analyze articles in *The Science Teacher* from 1998 to 2007, in order to study the implementation of inquiry in science classrooms. Those articles were used to analyze the features of inquiry-based science teaching in classrooms. It is surprising to find that only a few articles described true inquiry-based teaching. Features such as explaining, making connections and justifying explanations are also less represented by the articles, which suggests that teachers see inquiry-based teaching more as a whole concept; as a learning experience rather than as discrete pieces or a media for teaching specific scientific content (Morrison, 2013; Asay & Orgill, 2010). Morrison explores six elementary teachers’ beliefs and their implementation of inquiry-based science teaching. From the research findings, it is interesting to see that teachers generally possess an idea of inquiry as “finding things out”
(Morrison, 2013, p. 578). Researchers also realize that teachers generally view inquiry as a doable task rather than something that is overwhelming to implement or takes a lot of planning (Morrison, 2013).

Seung et al. focus on exploring the understanding of experienced teachers about the 5 essential features of inquiry-based teaching (2013). Researchers found that teachers had difficulty connecting appropriate inquiry features to each science teaching episode (students’ field experience videos), which indicates their lack of understanding of the concept of inquiry-based science teaching. It is interesting to find that teachers tend to pay more attention to and spend more time on student engagement of scientific questions, data collection and diagnostic assessment. Features not mentioned are formulated explanations from evidence, evaluated explanations using science language, communicate explanation (Seung, Park, & Jung, 2013). Researchers explain that these later three features are more challenging for teachers to understand and implement into teaching (Seung, Park, & Jung, 2013). According to the findings, this result is due to a teacher-centered perspective rather than a student-centered perspective, which focuses more on data collecting and drawing conclusions than idea critiquing (Seung, Park, & Jung, 2013).

It is also evident that a great number of case study lessons were not connected to any inquiry feature, but tended to focus on classroom management skills rather than science teaching itself. Research shows that teachers concentrate more on the parts that work, in terms of student engagement or classroom management rather than on the theoretical or propositional knowledge (Seung et al., 2013; Ireland et al., 2012). Researchers find that although pre-service teachers defined and implemented inquiry teaching as highly student-directed at the beginning of the semester. As they encountered
instructional challenges and focused on students’ increasing learning needs, pre-service teachers’ lessons became more teacher-directed (Biggers & Forbes, 2012)

**What are important elements for a teacher when they incorporate inquiry-based practices into a science lesson?**

Researchers focus on the purpose of teachers when teaching inquiry-based science lessons. In research done by Ireland et al., researchers categorize six inquiry teaching approaches used by exemplary teachers into three categories (2014). Six inquiry teaching approaches include: free inquiries, illustrated inquiries, solution inquiries, method inquiries, topic inquiries and chaperoned inquiries (Ireland, Watters, Lunn Brownlee, & Lupton, 2014). Researchers then categorized those approaches into three categories: experience-centered category (free and illustrated inquiries), problem-centered category (solution and method inquiries) and question-centered category (topic and chaperoned inquiries) (Ireland, Watters, Lunn Brownlee, & Lupton, 2014). It is important to address the fact that each category fulfilled different learning goals in terms of the science curriculum. In their former study, researchers discuss each category’s purpose of inquiry: the experience-centered category emphasizes providing fun experiences for students; the problem-centered category emphasizes motivating through solving interesting problems; and the question-centered category emphasizes encouraging students to ask questions and solve their own problems (Ireland et al., 2012). Researchers also analyze and evaluate the inquiry level of these three categories, and they conclude that Category 3 is the most inclusive way of experiencing inquiry-based teaching among the three category (Ireland et al., 2012).

Other researchers have not developed a systematical framework to analyze the purpose of inquiry. However, most of them observed that teachers put more emphasis on
preparing students for the investigative process; teachers prioritize promoting students’ interests in science over scientific content learning. (Poon et al., 2012; Furtak & Alonzo, 2010). It is evident that teachers believe that the students would learn more through “hands-on” lessons, which includes interacting with materials. Therefore, teachers hold a misinterpretation of the goal of inquiry-based teaching, which leads the teacher to ignore more cognitive or content-related goals of science teaching. (Furtak & Alonzo, 2010). Those findings helped to form this research framework and reveal the relationship between teachers’ practice and their theoretical understandings of teaching/learning.
Chapter 3: METHODOLOGY

This research project is an exploratory case study about elementary teachers and their beliefs about inquiry-based teaching. The section will provide an overview of the methods, research participants, data collection and analysis of data. An outline of the schedule and process will be provided.

Procedure

This study is based on the understanding that the beliefs of teachers about science will influence their way of teaching inquiry-based science and determine their effectiveness of implementing inquiry-based activities. In order to promote inquiry-based science teaching in elementary science classroom, this study aims to gain an understanding of elementary teachers’ understanding towards inquiry-based science teaching as well as their ways of implementation and figure out the gap between the understanding of teachers and researchers.

This study draws on qualitative data from semi-structured interviews with three elementary teacher-participants. This type of interview was preferred for its practicality and potential to elicit significant depth in addressing the research questions, allowing participants the freedom to discuss understandings related to inquiry-based science teaching. Some questions that were asked were: describe a non-example of inquiry-based learning; what are the roles of a teacher in your science class? (If any); which aspects of the investigation were effective, or ineffective, in terms of reaching your learning goals with students and why? (Appendix B). In order to give participants time to prepare, the interview questions were sent one-day prior to the interview. Consistent with the nature of qualitative inquiry, interviews were conducted in participants’ natural setting where
they foster inquiry-based learning. Interviews were recorded and subsequently transcribed.

**Instruments of Data Collection**

The protocol of this research included a comprehensive literature review, which provided a theoretical background and context for the study. Related studies were reviewed to identify questions needed to be addressed, and to guide the design of interview questions. For example, research illustrates that the understanding of teachers about the essential features of scientific inquiry should be included when discussing inquiry-based science teaching. Therefore, the interview includes the question: what are some of the key features of inquiry-based teaching? Moreover, the question, “what aspects of your lesson illustrate the presence of, or absence of, the features of an inquiry-based lesson?” investigates the implementation of the scientific inquiry features through teachers, and reflects on their understanding of inquiry-based science teaching. Data was collected from three participants who teach inquiry-based science. Each 20-30 minutes interview involved face-to-face interactions where the participants were asked a series of open-ended questions. The third interview was conducted through a short PLC meeting where several teachers shared their understanding about the features of inquiry-based science teaching, as seen in the teachers’ role and in the students’ role. Interviews were transcribed, followed by an analysis of common meanings from participants’ experiences with inquiry-based science teaching (Creswell, 2013). The full interview protocol can be found in Appendix A.
Participants

Potential participants were contacted through associate teachers in my placement as well as my research supervisor. Three participants were selected according to the following criteria: full-time teachers who taught primary grades for at least five years and have taught a successful (from their own perspective) inquiry-based science lesson and who are committed to encouraging scientific inquiry during science teaching. One of the participants should have attended a professional inquiry-based training session.

Data Collection and Analysis

During the interview, teachers will be asked to provide classroom examples of inquiry-based activities. Teachers were also asked for evidence of inquiry-based lessons (e.g., photos of student work). A data collection schedule (including the type of data collected) was provided in Table 1.

Table 1 Data Collection Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Teacher’s Name</th>
<th>Grade of Teaching</th>
<th>Types of Data Collected</th>
<th>School Board / School Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec. 04, 2014</td>
<td>Linda</td>
<td>Grade 3</td>
<td>Interview</td>
<td>TDSB</td>
</tr>
<tr>
<td>Dec. 04, 2014</td>
<td>Mary</td>
<td>Kindergarten</td>
<td>Interview and photos of students’ work</td>
<td>TDSB</td>
</tr>
<tr>
<td>Feb. 19, 2015</td>
<td>Anna</td>
<td>Kindergarten</td>
<td>- Interview with teacher individually - Interview through a small PLC meeting</td>
<td>Independent laboratory school</td>
</tr>
</tbody>
</table>

The audio interviews were transcribed for data analysis. After transcribing the interviews, similarities and differences were identified and then organized for further
coding. Then, the transcript was coded, and differently coloured markers were used to indicate different parts of the transcript that fell into different categories. Therefore, the primary categories and sub-categories were developed according to the possible codes, the original research questions and literatures. The two categories are the understanding of teachers about inquiry, and its implementations, and the sub-categories included in the understanding of inquiry are 1) features of inquiry and 2) teachers’ role in inquiry-based science teaching, while the sub-categories included in the second category are 1) purpose of inquiry, 2) implementation challenges. The complete Table of Data Analysis Genesis can be found in Appendix C. Table 2 is the coding schema that was developed according to the theoretical literatures and interview data:

**Table 2 Coding Schema**

<table>
<thead>
<tr>
<th>Coding category</th>
<th>Code</th>
<th>Coding description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers’ understanding about inquiry</td>
<td>Prepare to investigate</td>
<td>- learners give priority to evidence in responding to questions, - students plan investigations - teachers guide thinking through key issues of investigation and introduce skills</td>
<td>They are able to copy and write the materials themselves. We have them write what they have made and plan to make. And then it allows us to see their pictures because it’s amazing even some of these senior kindergarten kids, sometimes the old kids could even draw in perceptive, it’s amazing. (Mary, Kindergarten, Dec. 04, 2014)</td>
</tr>
<tr>
<td></td>
<td>Investigate</td>
<td>- learners formulate explanations from evidence, - students investigate the problem or to derive knowledge claims</td>
<td>…the kids are out there, they are exploring…(Mary, Kindergarten, Dec. 04, 2014)</td>
</tr>
<tr>
<td></td>
<td>Prepare to report</td>
<td>- learners connect explanations to scientific knowledge - small groups prepare to report - teachers may guide students to articulate ideas and impart report skills</td>
<td>…I asked Why you think it happened. And they said because it is bumpy. And I asked why would bumpy made a difference. Well they couldn’t go pass that, I introduced friction because they cannot into that word and that’s not a word they disposal, that’s not a common word for them yet, now it’s the perfect time to bring it in, now it’s time to get them rub their hands together and then rub it on the carpet to feel the difference and feel that experience of what friction can create and so bringing in information, bringing in vocabulary, bringing in the book. (Anna, Kindergarten, Feb. 19, 2015)</td>
</tr>
<tr>
<td></td>
<td>Report</td>
<td>- learners communicate and justify</td>
<td>They just stand in front of the class and they explain</td>
</tr>
</tbody>
</table>
**Explanations**
- students report their findings and defend ideas
- whole class evaluation and discussion

what they’ve made. They have to tell you what the materials they used, what they made, they show the picture. (Mary, Kindergarten, Dec. 04, 2014)

**Teachers’ role in inquiry-based teaching** (Furtak, E. M., & Alonzo, A. C., 2010)

<table>
<thead>
<tr>
<th><strong>Facilitator</strong></th>
<th>Teachers facilitate children among their learning process</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>…giving the kindergarten kids a variety of materials and having them explore…(Mary, Kindergarten, Dec. 04, 2014)</td>
</tr>
<tr>
<td></td>
<td>Ur.. you are facilitating, you are preparing them with the concepts, providing them with words, showing them visuals, it could be anywhere form pictures to videos on a specific topic on science. (Linda, Grade 3, Feb. 19, 2015)</td>
</tr>
</tbody>
</table>

**Informing**

Teachers tell what children should do among the learning process.

…sometimes when you glue it if you lie flat then the structures come off. So I’ll helped them and say why don’t you do it flat. (Mary, Kindergarten, Dec. 04, 2014)

**Teachers’ implementations of inquiry**

Purpose of inquiry (Furtak, E. M., & Alonzo, A. C., 2010)

<table>
<thead>
<tr>
<th><strong>Content</strong></th>
<th>Teaching for scientific content (referring only to canonical type of knowledge)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>We do have a big idea where we might go. But we are really open and flexible said so that what we do today will do determine what we do tomorrow. We don’t know what tomorrow is going to look like until today has happened. (Anna, Kindergarten, Feb. 19, 2015)</td>
</tr>
<tr>
<td></td>
<td>To learn specifically more about magnets. (Linda, Grade 3, Feb. 19, 2015)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Process</strong></th>
<th>Helping students to learn about how to do science, e.g., learn how to measure, record</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>…if the students are a little bit older, they can follow what do you call it.. the scientific order? The things, you know, predicting the first, and observing, doing the experimentation and then write up the conclusion, that would be the role of students. (Linda, Grade 3, Feb. 19, 2015)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Problem solving</strong></th>
<th>engaging students with challenging questions and solving problems</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>so we do it, so why do you think that happened, and they said because it is so light. Oh because it is so light. Then let’s begin with the baby light object. So you drop those two things and it still fell down soothing. Because it is light, so here is another piece of paper, and these two pieces of paper are the same, so I am going to crumple this one up, is this heavier now or is this still the same piece of paper? it is just a different shape, but what’s going to happen now if I drop them, so they predicted that one is going to drop down, why this one is going to drop down? (Anna, Kindergarten, Feb. 19, 2015)</td>
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<th><strong>Affectivity</strong></th>
<th>Fun, develop interest in science (general), sense of accomplishment</th>
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<td>…because it’s all ties into motivation and the kids are more interested in what they are doing. And the kids enjoy doing it and they want to. This whole building in all took off because my class loves to build. And they just expanded and expanded because we based on the kids interests. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<th><strong>Other</strong></th>
<th>Language, math, arts or other non-science related purposes</th>
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<td>So it really tie in a lot of language, um, a lot of language bullets too because the children are spending a lot of time, writing, talking, reading, writing. So it’s not just science based, it’s really binging in other course subject. (Mary, Kindergarten, Dec. 04, 2014)</td>
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Implementation Ability/Challenges (Samuel, D. F., & Ogunkola, B. J., 2013)
Classroom management | Challenges of classroom management | I thought my centers did run smoothly, but I think I would tweak a little bit by just being more organized and having students probably doing a project afterwards. (Linda, Grade 3, Feb. 19, 2015)

Pairing | Challenges of pairing students up. | So I think that is the most challenging thing is pairing kids the right partner and having them work well together. Not having one child take over. (Mary, Kindergarten, Dec. 04, 2014)

Material | Challenges of getting materials. | In terms of challenges, I think lots of them are the materials challenges, combining the materials, collecting materials... (Linda, Grade 3, Feb. 19, 2015)

Understanding of scientific content | Challenges of understanding the scientific content. | Because you never know fully you know, how deeply the children are going to go, so it means as a teacher, that I constantly doing my own work to figure out what is this concept that we are trying to understand and one has to feel comfortable with that state, that doesn’t mean that I am being irresponsible that, ur you know “the children will know more than I will”. We are call to deepen our own understanding and identify our misconceptions along the way. (Anna, Kindergarten, Feb. 19, 2015)

**Ethical Review Procedures**

The researcher followed the ethical review approval procedures for the Master of Teaching program as well as the Toronto District School Board. Ethical issues that could be involved in this study include data collection and data analysis. The researcher was the only person responsible for collecting and assessing the survey and interview data. Since the research topic includes the teacher's own perspectives and teaching philosophies, trust in the relationship between researchers and teachers is very important. During this study, a trusted relationship with participants was maintained so that they felt more comfortable and engaged in the study. Confidentiality was one of the most important ethical components. All the names of students and teachers will not be shown in any part of the study, and their true identities cannot be determined by readers through the study. Permission is required to access any of the works and materials provided by the teachers.
Chapter 4: FINDINGS

This study identifies two overarching themes for inquiry-based elementary science teaching. First, teachers have some degree of understanding about inquiry-based science teaching; however, this understanding may not be correct. This influences their conceptions about the features of inquiry, and the roles that the students and teachers play in inquiry-based activities. Secondly, teachers have preconceived notions about how implementation of inquiry-based science lessons should occur. This is reflected in the purpose or objectives of their lesson and the challenges seen in the implementation of the inquiry-based science lesson.

The following narrative gives context to the three teachers in this study.

Case Study 1: Linda was an experienced grade 3 teacher who believed that she was teaching in an inquiry-based approach. In her class, she described students exploring magnets by playing with magnets in different ways. She organized her class so that she provided the students with questions, and then instructed students to use magnets. Linda allowed students to record their observations, and then draw their own conclusions. She always made the students follow the scientific method in a very structured way. When asked what her definition of scientific inquiry was, she commented: inquiry-based learning is all about having the students gain an interest in something related to science.

Case Study 2: Mary was an experienced grade 1 and kindergarten teacher who think she was using an inquiry-based approach. She described inquiry-based science teaching as a hands-on learning approach, which is learning by doing. She had students exploring and playing with different materials, and then allowing them to work collaboratively to build a variety of structures. She put more emphasis on the students’ interests and motivation of learning. She let students choose the materials they want to
use, and design and build whatever structure they want. She did not have a specific learning goal for the case study lesson, and the design of this lesson is based on students’ interests of building. She believed that a teacher standing in front of the class reading a book is not inquiry-based teaching. Her definition of inquiry-based science teaching is doing a lot of hands on activities where the students are exploring and working from their interests.

Case study 3: Anna is an experienced inquiry-based elementary teacher working at a laboratory school. She is considered to be a professional inquiry-based science teacher. She is passionate about inquiry-based teaching, and she had unique ways of seeing and understanding inquiry-based teaching. She described how she used questions and small experiment to challenge students to think and ask questions so that they could gain a deeper understanding about a scientific concept. She also focused on the teaching of science concepts, vocabularies and the method of communicating findings. She believed that the primary focus of inquiry-based science teaching is the motivation of students, and teachers should have a big picture of what and where the learning would or should be happening.

The excerpts below are from the interview data of the three elementary teachers (Linda – Grade 3 teacher; Mary – Kindergarten teacher; and Anna – Kindergarten teacher). These excerpts highlight the overarching themes (and subthemes). Comparisons between teachers in regular public schools, (Linda and Mary) and a teacher who worked in a Laboratory school and had professional inquiry-based training (Anna) will be made under each subtheme.
Teacher’s understanding about inquiry-based science teaching

Within the theme of the understanding of inquiry-based science teaching, participant responses are further categorized into the features of inquiry-based science teaching, and the students’ and teachers’ roles in inquiry-based teaching. It is important to note that the first subtheme, the features of inquiry-based science teaching, includes teachers’ conceptions about the definition of inquiry and the five essential features of inquiry-based teaching adapted by Bybee (2010).

Features of inquiry-based science teaching

Linda and Mary had very broad definitions of inquiry, and saw inquiry as a process of exploring through interacting with materials and gaining interests from materials. The case study inquiry lesson involved students ‘doing hands-on’ activities and ‘working with materials’. In addition, teachers also tried to make real world connections as students worked with various materials and performed tasks. For example, one participant explained why she thought her lesson was inquiry-based:

I think it allows the children to explore and use a variety of materials and to learn about which materials glue better together, what it gear together, what paint sticks to, what paint doesn’t stick to. Just really allowing them to explore a variety of materials and use their imagination and creativity. (Mary, Kindergarten (Dec. 04, 2014))

Linda revealed her opinions towards the outcome of inquiry lesson. She mentioned that inquiry should give students the freedom to explore without being concerned about the result being right or wrong. Both teachers focused on the process and the experience of doing an experiment, rather than the content knowledge of science. Linda explained why her lesson was inquiry-based:

I think the lesson was inquiry-based because students were involved in the exploration, they took part in every aspect of the lesson, so it was hands-on learning, it was investigation on their own, there were no right or wrong answer,
and students were able to form a conclusion afterwards. (Linda, Grade 3 (Dec. 04, 2014))

Anna, who had professional inquiry-based training considered inquiry-based teaching as a process of knowledge building. She believed that inquiry-based science teaching does not mean simply giving out information but giving students the opportunity to talk about their ideas, explore things, and acquire information that is helpful. Compared with Lina and Mary, Anna has a deeper understanding of inquiry-based science teaching, which means more than hands-on activities. Inquiry-based science teaching for Anna involves helping students ask questions and think critically about the concept, and motivating them to explore more. Anna explained what inquiry-based teaching means to her:

You are not deciding in head of time exactly what the kids are going to be doing, and learning, and saying and being tested on. You try to build upon a big ideas that you think are interesting, inspiring and useful. And then, you know, find a way through that, that lets the kids feel very engaged in their thinking. Along the ways, so that you are constantly bringing them into the process of what are we going to do next, what’s going to help us understand next in a deeper the way; what do we need to know more about it. Making a point saying that we are so motivated by having the kids be motivated. That’s goanna to be the primary focus. That means keeping them as energy going, take keep this on. That it’s not just about following the children’s ideas. (Anna, Kindergarten (Feb. 19, 2015))

This study adopts Bybee’s (2010) five essential features of inquiry as an analytical framework for the understanding that teacher has towards inquiry as it is relevant to teachers’ classroom practice. The first feature analyzed is that the learner engages in scientifically oriented questions. The analysis of Linda’s and Mary’s interviews raise awareness that although teachers recognize that students should engage in scientific questioning, these questions are often raised by teachers. This indicates that teachers still hold a teacher-centered perspective of science teaching (Morrison, 2013). When talking
about an example of inquiry-based teaching, Linda said she would have the students explore the activity centers on their own “…but as a teacher you know, providing the appropriate questions, for instance, “what object do you think will sink or float?” (Linda, Dec. 04, 2014). Teacher who had professional inquiry-based training allowed students to predict, then perform the experiment, and then relate the results to the students’ past experiences to inspire the students to asking questions. Different from Linda and Mary, Anna believed that it is important to encourage students to ask their own questions. An important way to engage students to think and ask question always begins with making predictions and building on their past experiences. Anna challenged student ideas about how gravity works on earth by starting with predictions: “we did a few experiment with a large, and heavier objects they were very familiar with, beside a very light small object they are familiar with, and ask them and always beginning with that and have an opportunities to make perdition, built on their experience.” (Anna, Feb. 19, 2015). After comparing their predictions and the result of the experiment, students would be more curious and start to think about why this happened, and want to find out the reason behind it. Linda mentioned that students need to make hypotheses first too, but she saw hypotheses as a significant part of the scientific process instead of a way of inspiring students to ask questions.

The second feature is that learner gives priority to evidence in responding to questions. Mary and Linda followed the procedure of the scientific process and talked about the investigation process being the result of cooperation between teacher and students. Teachers need to provide the accessible materials for students to investigate and think about major issues of the exploration, while students might work cooperatively with other students and follow the teachers’ guidance and the scientific process. Moreover,
teachers have the preconception that teachers should provide students a process as a guide to investigate.

“…so then we have this special sheets where it says, um, what do you planning to make? They are able to copy and write the materials themselves. We have them write what they have made and plan to make. We need to provide whatever it is necessary for the students whether it could be a hands-on learning, you know, bring in objects into the classroom, so asking them to predict or make a hypothesis at first. Let students investigate into the question to find evidence, and formulate their explanations and present their conclusion.” (Mary, Dec. 04, 2014)

By analysing Anna’s case study lesson, the process of investigation seems very flexible and the process is embedded in a conversation:

….and the idea was try that with anything that we could drop would go straight down. While some students said what if we drop paper, well I think paper would be different. So we get paper out and before we drop the paper, what do you think would happen? They all wash their hands back and forth, they cannot articulate: well it is going to flow, it’s going to bend… so we do it, so why do you think that happened, and they said because it is so light. Oh because it is so light. Then let’s begin with the baby light object. So you drop those two things and it still fell down soothing. Because it is light, so here is another piece of paper, and these two pieces of paper are the same, so I am going to crumple this one up, is this heavier now or is this still the same piece of paper? it is just a different shape, but what’s going to happen now if I drop them, so they predicted that one is going to drop down, why this one is going to drop down? Because it is not flat, it is not spread out.

Teachers scaffolded students in the activity, and students were actively engaged to be part of the conversation. Anna believed that to promote inquiry-based learning, questions should be asked to challenge students’ preconceptions and misconceptions, while building on their experience.

The third feature is that the learner formulates explanations from evidence. When formulating explanations from evidence or investigation, teachers rarely mentioned terms like “explanations” and “using scientific language”. Mary and Linda tended to provide students with the opportunities to play around with
materials and to explore the materials freely within a group or individually. Furthermore, teachers tend to use the term “play around” or “explore” to describe the investigation stage. One of the participants commented on the investigation process:

we played around the magnets by using them under glass, put a paper on top and so all the magnets would move and we played games, and they were able to explore on their own…(Linda, Dec. 04, 2014)

Mary also mentioned that during the investigation process, kids need to do things “in order” and follow their own interests.

…doing a lot of, a lot more hands on, um, activities where the children are doing in order…having them explore, work with the materials, and make things that interest them…(Mary, Dec. 04, 2014)

Furthermore,

…doing an experimentation with a large or a small group exploring things on their own, even so setting a learning center for students to just go and explore whenever their feel like it…(Linda, Dec.04, 2014)

The fourth feature is how the learner connects explanations to scientific knowledge. It can be found that teachers did not make connections between the students’ investigations and scientific knowledge and explanations. It is clear to see from the interview that when Mary and Linda described their lessons, they did not connect explanations to scientific knowledge much. After investigating, students were sent into small groups to discuss their findings, and the scientific knowledge was either superficially connected or not connected with what they had done at all. For example, Linda talked about what students would do after the investigation:

…to work collaboratively with other people at their table, because they usually have a group of kids working together, and then, talking about it in finding what they have learned. (Linda, Dec.04, 2014)
Mary also mentioned that after the kids had built the structure, instead of relating it to scientific knowledge, she related it to literacy.

…and then actually after they built it, I had them describe a story. And then I typed the story and I put the story on their, on their structures. So they also have the stories go along with it. (Mary, Dec. 04, 2014)

Unlike Mary and Linda, Anna connected the investigation to scientific concepts and guided students to articulate ideas, which built on the students’ former knowledge and connects to their real life experience:

…I asked why you think it happened. And they said because it is bumpy. And I asked why would bumpy made a difference. Well they couldn’t go pass that, I introduced friction because they cannot into that word and that’s not a word they disposal, that’s not a common word for them yet, now it’s the perfect time to bring it in, now it’s time to get them rub their hands together and then rub it on the carpet to feel the difference and feel that experience of what friction can create and so bringing in information, bringing in vocabulary, bringing in the book.

The fifth feature is that the learner communicates and justifies their explanations. Every teacher had many different ways to allow the students report their findings, and it seems that some teachers put more emphasis on finding creative ways for students to report their findings. Moreover, all of the teachers organized whole class discussion, peer review, teacher feedback and evaluation towards students’ findings.

We posted what the children have made so that they are able to talk and share what they’ve made….and then they present it to the class. Every time they are done, they presented in front of the class. And the kids, in the audience, have to say something they like it but they need to say “I like it because…” and they need to give a reason. They need to explain what they’ve made. They have to tell you what the materials they used, what they made, they show the picture. (Mary, Dec. 04, 2014)

…and at the time the grade 3s can hypothesis, observe and draw their observation and write a conclusion afterwards, and what I saw was that everyone was engaged and everyone was interested, because that interest, they all gave me a very good report afterwards. They wrote about what they’ve observed, what
they predicted what happen when they observed what they concluded about their understanding about magnets. And they were able to and interact with each other and they are able to form a conclusion afterwards. (Linda, Dec. 04, 2014)

… and we would always say at that point and say so here is a piece of paper, we are going to write down what you noticed, what is one thing that you noticed, and then children can pick one thing and they also draw it. So there are lots of different ways for them to communicate that. (Anna, Feb. 19, 2015)

**Understandings of teachers’ role in inquiry-based science teaching**

All of my three participants expressed their thoughts about the role of teachers in inquiry-based science teaching, and they all believe that teachers do have a role in the classroom. None of them expressed the idea that teachers should let students do what they want without any instructions or guidance. They all hold the opinion that teachers should be the facilitator in an inquiry-based science classroom; however, teachers believed that teacher should also have the role of informing sometimes.

When they were asked about the roles of a teacher in inquiry-based teaching, all of the teachers mentioned that teachers should be facilitators in terms of providing materials and time, assisting students during exploration, helping students to do things beyond their capability (such as typing) and pairing students up.

…giving the kindergarten kids a variety of materials and having them explore…And to give them time to explore and to facilitate. And then to really, and when the kids are working, to really spend the time and hear them and listen to them, and find what they want to learn more about and working from their interests. I actually pair them in groups of two, myself, so I made the grouping for this, for the big structure….And then I typed the story and I put the story on their, on their structures. So they also have the stories go along with it. (Mary, Dec. 04, 2014)

Moreover, teachers believe that teachers have a strong role in inquiry-based science teaching, which guides the learning trajectory of students and designs their big picture of learning.
That the teacher is holding a very strong thread in their mind of what the trade trajectory should or could look like. But we are not being flexible about that. We are learning the children move where they might be going. But we are actually holding a big picture of what the learning would or should be happening, where the learning would or should be happening. (Anna, Feb. 19, 2015)

However, teachers also sometimes provide ideas for students or influence the thoughts of students for the sake of classroom management. Most importantly, teachers do not see that as a informing role but rather a facilitating role, because the providing or influencing of ideas contributes to a better learning result. For example, when Mary talked about her role in the inquiry-based lesson, she said:

…and sometimes we sway them one way or the other slightly like when we have birds. I said” hey, do you guys want the birds where could the birds be.” Things like that. So sometimes we sway them but it basically just working from the kids’ interests and using the materials that provided in the class…Sometimes we help them a little bit but generally speaking most of them done it them self. (Mary, Dec. 04, 2014)

Linda talked about the role of facilitator from the aspect of students’ learning and facilitating students’ thinking and knowledge building:

So providing all those choices to the students and having them chose a center of a choice. Ur…you are facilitating, you are preparing them with the concepts, providing them with words, showing them visuals, it could be anywhere form pictures to videos on a specific topic on science. Ur…providing whatever is necessary for the children or students to explore, let them go on explore, even gaining interests to explore something related to science. (Linda, Dec. 04, 2014)

The informing role was not mentioned by the teachers; however, it can be analyzed from the teachers’ description of their lessons. An informing role is that a teacher tells what children should do during the learning process. From the teachers’ descriptions, it is clear that teachers are the ones who design the learning process for students, including the content of learning, the hands-on activities that students do,
the materials they use, the way students present the info, the way of evaluation or even some guiding questions.

And the ECE and I started to think about what else can they build and that was actually her idea to give them straws and to give them pipe cleaners. We have them write what they have made and plan to make. And then it allows us to see their pictures…I also had them describe a story…sometimes when you glue it if you lie flat then the structures come off. So I’ll helped them and say why don’t you do it flat. (Mary, Dec.04, 2014)

…but as a teacher providing you know the appropriate questions, for instance, “what object do you think will sink or float?” so asking them to predict or make a hypothesis at first and then perform the experimentation. (Linda, Dec.04, 2014)

**Teachers’ Implementation of Inquiry in the Classroom**

Within teachers’ implementation of inquiry in the classroom, teachers’ implementation of scientific inquiry was analyzed from two aspects, the essential goal of their inquiry-based lesson and the challenges they have in implementing inquiry-based lesson. Therefore, the subthemes include the purpose of inquiry-based science lesson and the challenges of implementation.

**Purpose of inquiry-based science lesson**

By analyzing the participants’ interview, the essential purpose of the teachers’ inquiry-based lessons were classified into five main purposes: content, process, affectivity, problem solving and other. The purpose of this content specifically refers to a canonical type of knowledge; the purpose of this process refers to wanting students to learn about how to do science or the scientific method; the purpose of affectivity refers to developing interest in science and gaining a sense of accomplishment; the purpose of problem solving refers to engaging students with challenging problems and solving the problem; and the other purposes refers to math, writing, reading or other non-science related purposes.
When elementary teachers are teaching inquiry-based lessons, they do not have a clear learning goal for students. It can be found from the interviews with Mary, that she rarely teaches specific science content in kindergarten but instead for students’ interests in exploring. Mary sees science as a hands-on course to let students make or build things and explore materials. In contrast, in higher primary grades, teachers put more attention on the learning of content because it is part of the curriculum. However, when Linda was asked about more specific content knowledge of the lesson, she could not explain in details and just reply that “to learn specifically more about magnets”.

To learn specifically more about magnets. That was part of the curriculum… they were able to have a better outstanding and a theory behind why magnets act the way that they do…their primary knowledge of magnets were not vest, but slowly as we build on and slowly as the student investigate about the magnets, they were able to form maybe make a deductive conclusion whether their theory or whether their prediction conclusion was correct or incorrect they were able to ur.. observe what they saw through the experimentation, and therefore form a conclusion about what they thought about magnets. (Linda, Dec. 04, 2014)

However, teachers that had professional inquiry-based training had a specific learning goal for students. Anna’s lesson had a big idea which was inspired by the curriculum but not limited by the curriculum expectation. She brought up the content of gravity, friction and air resistance in her kindergarten class and introduced a variety of scientific vocabularies. For example:

So we were working on astronomy yesterday and the children from JK/SK we were exploring how gravity works in space and on earth. So obviously it is very difficult to find out and have an experiment working in the space, so we can look at how gravity work on earth…
…We were using ramps, having things roll or slide down from the ramp, we are trying to get the idea of friction, so the same way, you know, we were moving into the idea of air resistance….so bringing in information, bringing in vocabulary, bringing in the book. (Anna, Feb. 19, 2015)
All of the case study lessons partially teach the process of either doing an experiment or building structures. The participants all consciously or unconsciously want students to learn something to do with science, for example learning how to experiment, observe and report. For example, teachers talked about kids learning how to use different materials and the process of making a stable structure during the lesson.

.... I think they’ve learned which materials work better, what’s the better fastener. Like if you glue it with white glue it sticks better than if you do it with a glue stick or a tape. I think they’ve learned a lot about put something heavy on top of something light it will fall down. I think they really learned a lot. (Mary, Dec. 04, 2014)

Linda put more emphasis on teaching experimental process in her lesson:

if the students are a little bit older, they can follow what do you call it.. the scientific order? The things, you know, predicting the first, and observing, doing the experimentation and then write up the conclusion. I think I reached the goals in a sense that they were able to learn how to make hypothesis how to observe, how to make a conclusion. So using that aspects into other scientific inquiry, so for example it could be rocks and minerals, or it could be tings about simple machines, so using that aspect of hypothesising of making observations or making conclusions taking along to another topic and so forth. Yeah, so I think it was effective. (Linda, Dec. 04, 2014)

The most significant purpose of using inquiry in science class is affectivity. Teachers all demonstrate a perspective that inquiry-based learning is for fun, enjoyment and excitement. Teachers see developing interests in science, and having a sense of accomplishment is a primary goal of inquiry-based teaching. No matter what teaching goal those teachers have, their primary teaching goal is to motivate students, to develop students’ interests in science, and to foster curiosity. Moreover, teachers always define a successful inquiry-based science lesson as engaging and that students “had lots of fun”.

I think inquiry-based learning is all about having the children or having the students gain an interest in something related to science. Exploration, having that curiosity that drives to learn. In kindergarten, that would be simply
exploration, gaining that interests, and curiosity to go further and beyond….it really wows the kids, it seems that everyone in the entire class was amazed and therefore, they were so much more interested in the learning about magnets…students were able to put their curiosity into the task. (Linda, Dec. 04, 2014)

Furthermore,

…I think their role is to stay on task to have fun…Just really allowing them to explore a variety of materials and use their imagination and creativity…because it’s all ties into motivation and the kids are more interested in what they are doing. And the kids enjoy doing it and they want to. (Mary, Dec. 04, 2014)

Anna also mentioned the significance of promoting motivation in inquiry-based science teaching:

You try to build upon a big ideas that you think are interesting, inspiring and useful. And then, you know, find a way through that, that lets the kids feel very very engaged in their thinking…. Making a point saying that we are so motivated by having the kids be motivated. That’s goanna to be the primary focus. That means keeping them as energy going, take keep this on. (Anna, Feb. 19, 2015)

Teachers who have had professional inquiry-based training see engaging student with questions, challenging students with questions and solving problems as the main purpose of inquiry-based science teaching. Among three participants, Anna is the only one who mentioned the purpose of teaching inquiry-based lessons is for engaging students with challenging questions and solving problems.

So we continued from there, and the idea was try that with anything that we could drop would go straight down. While some students said what if we drop paper, well I think paper would be different. So we get paper out and before we drop the paper, what do you think would happen? They all wash their hands back and forth, they cannot articulate: well it is going to flow, it’s going to bend… so we do it, so why do you think that happened, and they said because it is so light. Oh because it is so light. Then let’s begin with the baby light object. So you drop those two things and it still fell down soothing. Because it is light, so here is another piece of paper, and these two pieces of paper are the same, so I am going to crumple this one up, is this heavier now or is this still the same piece of paper? it is just a different shape, but what’s going to happen now if I drop them, so they predicted that one is going to drop down, why this one is going to drop down? Because it is not flat, it is not spread out. So the
whole time challenging them, challenging with their preconceptions challenging their misconceptions, but also building on their experience, you can see how excited they will be getting that because they knew what was going to happen as soon as they saw the objects even before they saw it happens. (Anna, Feb. 19, 2014)

Other purpose that teachers implement scientific inquiry is for purposes that are not related to science learning purposes, such as reading, writing or math etc. Teachers find it important to integrate inquiry-based teaching in other subject areas to support student learning in all domains. For example,

…even so setting a learning center for students to just go and explore whenever their feel like it, but again integrating language and math at the same time into the science. And ..and to tie with that, I incorporative art as well and always language into it. (Linda)

so we’re looking at the growth of their understanding within that the content of that inquiry, but we are also looking at how that inquiry is supporting perhaps their understanding in math, how they are able to use other areas of academic or intellectual skill growth to support what they’re learning in vice versa, so we do want to see that inquiry is also embedded within writing that they are doing, different ways of communicating whether it’s oral or through a PowerPoint or whatever, we are looking at their growth in all the domains that would be what we want to see it happens. (Anna, Feb. 19, 2015)

**Challenges of implementing**

The challenges of implementing inquiry-based science lesson were classified into four sections: classroom management, pairing, materials and understanding of scientific content. From the findings, it can be found that teachers tend to focus more on the practical aspects, such as classroom management and how to make learning more organized and smooth; however, none of them dug deep in their conceptions or understandings towards scientific inquiry. They care more about how to pair students up so that students can work well. Most importantly, teachers put more emphasis on the challenges of getting materials. Mary and Linda talked about how difficult to get
materials and how to modify the materials so that kids could use it easier. For example, Mary talked about how she get the materials and how she modify them:

…Maybe get more material, provide more materials than what we had in class. Sometimes the painting is hard because some of the boxes are eliminated and the paint doesn’t stick. So maybe some of the boxes needed to be primed before they could be painted. (Mary, Dec.04, 2014)

Only one participant identified that the teacher’s knowledge about science could be a challenge of implement inquiry-based teaching. She said that:

…because you never know fully you know, how deeply the children are going to go, so it means as a teacher, that I constantly doing my own work to figure out what is this concept that we are trying to understand and one has to feel comfortable with that state. We are call to deepen our own understanding and identify our misconceptions along the way. (Anna, Feb. 19, 2015)

Therefore, teachers should be more aware of the importance of professional development.
Chapter 5: DISCUSSION

This study identified elementary teachers’ beliefs of inquiry-based science teaching and how they implement inquiry-based science teaching. This study supports previous research on inquiry-based teaching by identifying similar connections and gaps between teachers’ beliefs of inquiry-based teaching and implementation of this strategy.

What are teacher beliefs of inquiry-based science teaching?

Teachers had a broad and distorted definition of inquiry. They refer to inquiry-based science teaching as having students’ exploring, doing hands-on activity and working with materials. They believe inquiry is a process of exploring through interacting with materials and gaining interests from materials. However, a number of researchers made it clear that inquiry is not simply a hands-on learning experience, a lab activity that verifies what has been taught, discovery learning, or a set of skills to be practiced (Asay & Orgil, 2010; Crawford, 2000; Huber & Moore, 2001; NRC, 2000, 2006; Trumbull et al., 2005). Therefore, as researchers stated, teachers misuse the term of inquiry and describe inquiry as discovery or hands-on learning (Morrison, 2013; Asay & Orgill, 2010; Crawford, 2000). However, teachers who have had professional inquiry-based training had a systematic understanding of inquiry-based teaching. One concept that developed from this research is the theory of knowledge building, and giving students the opportunity to talk about their ideas and explore things (Anna, Kindergarten, Feb.19, 2015)

Through analyzing case study lessons based on Bybee’s (2010) five essential features of inquiry (learner engages in scientifically oriented questions, learner gives priority to evidence in responding to questions, learner formulates explanations from evidence, learner connects explanations to scientific knowledge and learner
communicates and justifies explanations), it can be found that teachers often neglected to promote students to raise their own questions. Although teachers understand that students should be engaged in scientific questions, teachers still raised the question, which indicates a teacher-centered perspective of science teaching. This conclusion is also supported by Morrison (2013). Teachers who had professional inquiry-based training encouraged students to make predictions, and then related the experiment to students’ past experience to inspire students to ask questions. Moreover, teachers rarely mentioned features like formulating explanations from evidence, connecting explanations to scientific knowledge and communicating and justifying explanations, which support Seung, Park and Jung’s (2013) assertions. Seung, Park and Jung (2013) believe that these three features are more challenging for teachers to understand and implement into teaching, and teachers focus more on students’ data collection and drawing conclusions than critique of ideas which is due to the teachers’ teacher-centered perspective. Teachers who have had professional inquiry-based training connected the investigation to scientific concepts and guided students to articulate ideas, which built on students’ former knowledge and connects their real life experience.

In terms of teachers’ roles, all participants agreed that teachers should have a strong role in the classroom and be the designer of the lesson while facilitating students along the learning process. Participants shared similar views with the literature that as teacher encountered challenges engaging in inquiry-based instruction and increasingly emphasized students’ learning needs, they began to plan and enact lessons that were more teacher-directed (Biggers & Forbes, 2012)
How did teachers implement inquiry-based science lesson?

The participants’ case study lessons were analyzed from two aspects, the essential goal of their inquiry-based lesson and the challenges they have in implementing inquiry. The purpose of teachers’ inquiry-based lessons can be classified into 5 main purposes: content, process, affectivity, problem solving and other. The purpose of the content specifically refers to a canonical type of knowledge; the purpose of the process refers to wanting students to learn about how to do science; the purpose of affective refers to developing interests in science and gaining a sense of accomplishment, the purpose of problem solving refers to engaging students with challenging problems and solving the problem and the other purposes refers to math, writing, reading or other non-science related purposes.

The study showed that when elementary teachers without professional inquiry-based training teach inquiry-based lessons, they do not have a clear content learning goal for students. However, all of the participants believed affectivity is an important purpose of teaching inquiry-based lesson. This conclusion is also supported by researchers, they found that teachers prioritize helping students to like science over specific content outcomes and emphasis on doing and feeling during inquiry-based lessons. (Poon et al., 2012; Ireland et al., 2012; Furtak & Alonzo, 2010). All of the participants mentioned teaching the process of how to do science, however, only the participant who had professional inquiry-based training perceived engaging students with questions, challenging students with questions and solving problems as a main purpose of inquiry-based science teaching. In addition, all of the teachers found it is important to integrate inquiry-based teaching in other subject areas to support students’ learning in all domains.
The challenges of teachers are basically around lack of materials, classroom management and grouping students, which is supported by Seung et al. (2013) and Ireland et al. (2012). Researchers found that teachers focus more on classroom management skills rather than science teaching itself and teachers concentrate more on the parts that work, in terms of student engagement or classroom management rather than on the theoretical or propositional knowledge (Seung et al., 2013; Ireland et al., 2012). Teachers who have professional inquiry-based training (and professional development) recognize the challenges of understanding the scientific content as being significant.

**Implications and Recommendations**

This study highlights the benefits of working with teachers and exploring their understandings in order to address possible misconceptions and gaps in their knowledge. It brings to educator’s attention that teachers have different understanding of inquiry-based science teaching and their ways of understanding inform their ways of implementation. It is important to notice that although inquiry-based teaching was promoted in elementary school for decades, some teachers are still holding simplistic opinions and understandings regarding inquiry-based teaching. Teachers need to deepen their knowledge and understanding about the science in order to teach it more effectively and to engage in a variety of teaching strategies (including inquiry-based learning).

In addition, this study offers some directions and suggestions for pre-service education faculties. The studies identified that teachers have a very broad understanding of inquiry-based teaching and this is based on the literal meaning. Some of them still follow the traditional way of science teaching (doing experiment and following scientific method) and assume they are teaching inquiry-based lessons. Therefore, it is important for teacher educators to clarify the definition of inquiry-based teaching and provide more
opportunities for pre-service teachers to practice inquiry-based teaching. Furthermore, teacher educators might involve inquiry-based teaching in not only science curriculum studies, but also in other subjects such as math and language arts curriculum studies, such that pre-service teachers might have more chances to approach to the concept and form a deeper understanding when they become in-service teacher.

In addition, the study suggests that teachers need a working knowledge of the features of scientific inquiry; along with specific ways to implement each feature. Misunderstandings should be clarified, in terms of distinguishing the difference between inquiry-based teaching and scientific methods or hands-on learning. Workshops should provide concrete examples and make resources available for teachers to refer to, and help them understand what inquiry-based lessons really look like. In terms of schools, more professional development opportunities and resources of inquiry-based teaching should be provided. Therefore, teachers can refresh knowledge of inquiry-based teaching consistently, share inquiry-based teaching resources and ideas and deepen their understandings of scientific inquiry.

Limitations

There are several limitations to this study. One of the limitations is the small sample size of participants. Only three teachers were interviewed due to the parameters of the Master of Teaching Research Project. The wider the different academic background of teacher participants, different teaching background and the science facilities in different schools are, the more variety of answers there will be. Two of my teacher participants have bachelor degree while the third participant has a master degree. Therefore, the understandings among the three teachers were quite different. In addition, the context the teachers were teaching in, namely the school environment had a variety of
supports to develop inquiry-based science teaching. This influenced the teachers’ implementation of inquiry-based teaching.

Other limitations were the length of the study (conducted over a one year period), which provided only a small window into the teachers’ perspective. In addition, within the ethical review protocol of MTRP researcher is restricted to only data from teachers and not students or classroom observation. This also limited the opportunities to understand how inquiry-based lessons were implemented.

**Consideration for Future Research**

This study provided insight into elementary teachers’ perspectives on inquiry-based science teaching; however, further research is required to explore student understandings of inquiry-based science and their perspectives. It is necessary to follow teachers’ implementation of inquiry-based science into the classroom and see how teachers revise or redesign their lessons based on the results. In addition, students learning about science concepts need to be assessed based on the strategy itself.

Other research considerations included teacher professional development. It was evident from this study that teachers require content based understandings of science and this impacted how they implemented inquiry-based science lessons. Teachers also need workshops that are specific to inquiry-based strategies. Recently, cuts in Ontario budgets to education, have impacted teacher professional development additional qualification courses with respect to science education. In addition, Boards of Education require more workshops that specifically address teachers’ needs for resources in inquiry-based learning. Further research is required to effectively and efficiently support teachers in inquiry-based science teaching.
REFERENCES


Appendix A: Letter of Consent for Interview

Date: ___________________

Dear ___________________,

I am a graduate student at OISE, University of Toronto, and am currently enrolled as a Master of Teaching candidate. I am studying ________________ for the purposes of investigating an educational topic as a major assignment for our program. I think that your knowledge and experience will provide insights into this topic.

I am writing a report on this study as a requirement of the Master of Teaching Program. My course instructor who is providing support for the process this year is Dr. _________________. My research supervisor is ___________________. The purpose of this requirement is to allow us to become familiar with a variety of ways to do research. My data collection consists of a 40 minute interview that will be tape-recorded. I would be grateful if you would allow me to interview you at a place and time convenient to you. I can conduct the interview at your office or workplace, in a public place, or anywhere else that you might prefer.

The contents of this interview will be used for my assignment, which will include a final paper, as well as informal presentations to my classmates and/or potentially at a conference or publication. I will not use your name or anything else that might identify you in my written work, oral presentations, or publications. This information remains confidential. The only people who will have access to my assignment work will be my research supervisor and my course instructor. You are free to change your mind at any time, and to withdraw even after you have consented to participate. You may decline to answer any specific questions. I will destroy the tape recording after the paper has been presented and/or published which may take up to five years after the data has been collected. There are no known risks or benefits to you for assisting in the project, and I will share with you a copy of my notes to ensure accuracy.

Please sign the attached form, if you agree to be interviewed. The second copy is for your records. Thank you very much for your help.

Yours sincerely,

Researcher name: ________________________________
Phone number, email: ______________________________

Instructor’s Name: ________________________________
Phone number: _______________ Email: ______________

Research Supervisor’s Name: _______________________
Phone #: ______________________ Email: ______________

Consent Form

I acknowledge that the topic of this interview has been explained to me and that any questions that I have asked have been answered to my satisfaction. I understand that I can withdraw at any time without penalty.

I have read the letter provided to me by ____________________(name of researcher) and agree to participate in an interview for the purposes described.

Signature: ________________________________

Name (printed): ________________________________

Date: ______________________________
Appendix B: Interview Questions

**Background information:**

1. How long have you been an elementary teacher?
2. What grades have you taught?

**Understanding of science inquiry**

3. Do you consider yourself an inquiry-based science teacher? Why or why not?
4. What are some of the key features of inquiry-based teaching?
5. Describe a non-example of inquiry-based learning
6. Describe an example of inquiry-based learning
7. What are the roles of a teacher in your science class? (if any)
8. What are the roles of students in your science class? (If any)
9. What are the roles of the community (class) in your science class (if any)?
10. What is your favourite science lesson? And Why?

**Strategies**

11. What aspects of your lesson illustrate the presence of, or absence of, the features of an inquiry-based lesson?
12. What are the learning goals for this lesson?
13. Why have you identified these as the learning goals for your lesson?
14. Why using inquiry is an appropriate, or inappropriate, approach for addressing your learning goals for the students?
15. What aspects of the scientific investigation were effective, or ineffective, in terms of reaching your designed learning goals with your students and why?
16. What would you change if you had a chance to reteach the lesson in the future with a different class?

**Challenges:**

17. What are some challenges that you encounter when organising and having an inquiry-based science lesson?
### Appendix C: Table of Data Analysis Genesis

<table>
<thead>
<tr>
<th>Coding category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prepare to investigate</strong></td>
<td>- students plan investigations</td>
</tr>
<tr>
<td><strong>Learner gives priority to evidence in</strong></td>
<td>- teachers guide thinking through key issues of investigation, may introduce skills, attitudes, beliefs</td>
</tr>
<tr>
<td><strong>Responding to questions,</strong></td>
<td>…so then we have this special sheets where it says, um, what do you planning to make? (Mary, Kindergarten, Dec. 04, 2014)</td>
</tr>
<tr>
<td></td>
<td>They are able to copy and write the materials themselves. We have them write what they have made and plan to make. And then it allows us to see their pictures because it’s amazing even some of these senior kindergarten kids, sometimes the old kids could even draw in perceptive, it’s amazing. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td></td>
<td>…And they got to get together; they have to talk, they have to decide one thing they are going to build. And then they built whatever they want. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<tr>
<td></td>
<td>…sometimes we sway them one way or the other slightly like when we have birds. I said” hey, do you guys want the birds where could the birds be.” Things like that. So sometimes we sway them but it basically just working from the kids’ interests and using the materials that provided in the class. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td></td>
<td>I believe it’s up to us, we need to provide whatever it is necessary for the students whether it could be a hands-on learning, you know bring in objects into the classroom. (Linda, Grade 3, Feb. 19, 2015)</td>
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<td></td>
<td>…so asking them to predict or make a hypothesis at first</td>
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<td></td>
<td>…so students were involved in all aspects, they bring in their own magnets, different kinds of magnets as well, different intensity…(Linda, Grade 3, Feb. 19, 2015)</td>
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<td></td>
<td>Certainly the idea of not just giving information, having kids ur, letting kids having a chance to talk about their ideas, explore things, and bringing information as it feels useful. (Anna, Kindergarten, Feb. 19, 2015)</td>
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<td></td>
<td>You are not deciding in head of time exactly what the kids are going to be doing, and learning, and saying and being tested on. You try to build upon a big ideas that you think are interesting, inspiring and useful. And then, you know, find a way through that, that lets the kids feel very very engaged in their thinking. Along the ways, so that you are constantly bringing them into the process of what are we going to do next, what’s going to help us understand next in a deeper the way; what do we need to know more about it. Making a point saying that we are so motivated by having the kids be motivated. That’s goanna to be the primary focus. That means keeping them as energy going, take keep this on. That it’s not just about following the children’s ideas. …. to be sure that we are talking about is a knowledge building to inquiry, if it is not a knowledge building, what is it, because we really know that children will have questions, but the teacher deep down knows the end result is some kind of performance on a test, then if that end result is in a view when they started, from our point of view, that couldn’t actually be completely knowledge construction, we would like to go deeper at what we can predict at starter because we know our students can. (Anna, Kindergarten, Feb. 19, 2015)</td>
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<td></td>
<td>… so we look through different resources to see what would be some interesting experiments to do in class with the children, to challenge their ideas about how gravity works on earth, so for example we did a few experiment</td>
</tr>
</tbody>
</table>
with a large, and heavier objects they were very familiar with, beside a very light small object they are familiar with, and ask them and always beginning with that and have an opportunities to make perdition, built on their experience.

some of the kids are going to say the small one is going to hit the table first because it is small and light, and some of kids are going to say the bear is going to hit the table first because it is big and heavy, and in fact, the kids were pretty much divided on that, but one child then said I think maybe they are going to hit the table at the same time, because when I drop things I think they fall at the same.

…and having that opportunity for kids to bring that up. (Anna, Kindergarten, Feb. 19, 2015)

We were using ramps, having things roll or slide down from the ramp, we are trying to get the idea of friction, so the same way, you know, we were moving into the idea of air resistance. And we were putting different things on the ramp, we knew the things that’s going to happen, because we had the bubble wrap on one of the ramp, and some of the kids thought it was going to go faster, and some thought it was going to go slower. In fact for most of the objects, they won’t move at all. (Anna, Kindergarten, Feb. 19, 2015)

<table>
<thead>
<tr>
<th>Investigate</th>
<th>students carry out activities to investigate the problem or to derive knowledge claims</th>
</tr>
</thead>
<tbody>
<tr>
<td>learner formulates explanations from evidence,</td>
<td>…the kids are out there, they are exploring…(Mary, Kindergarten, Dec. 04, 2014)</td>
</tr>
<tr>
<td></td>
<td>The kids in my class made a variety of structures with a variety of materials. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td>…and they make something and then they glue it and they paint it…(Mary, Kindergarten, Dec. 04, 2014)</td>
</tr>
<tr>
<td></td>
<td>then perform the experimentation, and then doing an observation…(Linda, Grade 3, Feb. 19, 2015)</td>
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<tr>
<td></td>
<td>Last time, it was using the dusting what is it.. ur.. the brush to dust away the sand, and students were…ur…their goals are to find dinosaurs fossil that was like one center, and the other one was using the magnets.. magnified glasses to observe all the different kinds of materials or rocks, or leaves, or whatever materials were available…(Linda, Grade 3, Feb. 19, 2015)</td>
</tr>
<tr>
<td></td>
<td>I think the lesson was inquiry because students were involved in the exploration, they took part in every aspect of the lesson, so it was hands-on learning, it was investigation on their own, there were no right or wrong answer, students were able to put their curiosity into the task, we played around the magnets by using them under glass, put a paper on top and so all the magnets would move and we played games, and they were able to explore on their own…(Linda, Grade 3, Feb. 19, 2015)</td>
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<td></td>
<td>So we continued from there, and the idea was try that with anything that we could drop would go straight down. While some students said what if we drop paper, well I think paper would be different. So we get paper out and before we drop the paper, what do you think would happen? They all wash their hands back and forth, they cannot articulate: well it is going to flow, it’s going to bend… so we do it, so why do you think that happened, and they said because it is so light. Oh because it is so light. (Anna, Kindergarten, Feb. 19, 2015)</td>
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<td></td>
<td>Then let’s begin with the baby light object. So you drop those two things and it still fell down soothing. Because it is light, so here is another piece of paper, and these two pieces of paper are the same, so I am going to crumple this one up, is this heavier now or is this still the same piece of paper? It is just a different shape, but what’s going to happen now if I drop them, so they predicted that one is going to drop down, why this one is going to drop down? Because it is not flat, it is not spread out. So the whole time challenging them, challenging with their preconceptions challenging their misconceptions, but also building on their experience, you can see how excited they will be getting that because they knew what was going to happen as soon as they saw the objects even before they saw it happens. (Anna, Kindergarten, Feb. 19, 2015)</td>
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</table>
…some of the kids said what if we make it even steeper, so we increase the incline and of cause didn’t change for some of them…(Anna, Kindergarten, Feb. 19, 2015)

<table>
<thead>
<tr>
<th>Prepare to report learner connects explanations to scientific knowledge</th>
<th>We posted what the children have made so that they are able to talk and share what they’ve made. (Mary, Kindergarten, Dec. 04, 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- small group prepare to report - teacher may guide students’ articulation of ideas &amp; impart skills</td>
<td>…and then they present it to the class. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td></td>
<td>Every time they are done, they presented in front of the class. And the kids, in the audience, have to say something they like it but they need to say “I like it because…” and they need to give a reason. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td></td>
<td>They just stand in front of the class and they explain what they’ve made. They have to tell you what the materials they used, what they made, they show the picture. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td></td>
<td>…then a conclusion at the end, that what I think. Sometimes they would draw the observations, for kindergartens, it is mostly about drawing, but for higher kids, they would write about what they observed. They would do a prediction as well, and then, they would draw or report their observations and do a write-up afterwards. (Linda, Grade 3, Feb. 19, 2015)</td>
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<td></td>
<td>So at the time the grade 3s can hypothesis, observe and draw their observation and write a conclusion afterwards, and what I saw was that everyone was engaged and everyone was interested, because that interest, they all gave me a very good report afterwards. (Linda, Grade 3, Feb. 19, 2015)</td>
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<td></td>
<td>They wrote about what they’ve observed, what they predicted what happen when they observed what they concluded about their understanding about magnets. (Linda, Grade 3, Feb. 19, 2015)</td>
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<td>and they were able to and interact with each other and they are able to form a conclusion afterwards…(Linda, Grade 3, Feb. 19, 2015)</td>
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<td>Another feature think is what we called honoring the misconception we called. the children come to me, they have been in a culture of this kind of idea sharing and knowledge building and they might not even call it that. Cause when they were in kindergarten, you know, some of them are just getting bell control for instance (laugh), you know, it’s a different way of talking to the children but the understanding is that we are building the ideas together and sharing ideas together. (Anna, Kindergarten, Feb. 19, 2015)</td>
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<td></td>
<td>… and we would always say at that point, at some point go back and say so here is a piece of paper, we are going to write down what you noticed, what is one thing that you noticed, and then children can pick one thing and they also draw it. So there are lots of different ways for them to communicate that.</td>
</tr>
<tr>
<td>Facilitator</td>
<td>Teacher facilitate children among their learning process</td>
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<td>-------------</td>
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<tr>
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<td>…giving the kindergarten kids a variety of materials and having them explore… (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td></td>
<td>…make things that interest them, and then talking about it in finding what they have learned… (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td>…to provide the materials for the children. And to give them time to explore and to facilitate. And then to really, and when the kids are working, to really spend the time and hear them and listen to them, and find what they want to learn more about and working from their interests. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td></td>
<td>…So we are collecting. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td></td>
<td>We also post outside my classroom… (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td>Just really allowing them to explore…</td>
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<td>I actually pair them in groups of two, myself, so I made the grouping for this, for the big structure. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td>…And then I typed the story and I put the story on their, on their structures. So they also have the stories go along with it.</td>
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<td>…I facilitate it by providing a box of material. I provide the materials for them, I provide the glue and sometimes we sway them one way or the other slightly like when we have birds. I said” hey, do you guys want the birds where could the birds be.” Things like that. So sometimes we sway them but it basically just working from the kids’ interests and using the materials that provided in the class. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td></td>
<td>…sometimes they will come to me and say “I need two eyes, I need two noses, I need a mouth, I need” Sometimes we help them a little bit but generally speaking most of them done it them self. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td></td>
<td>…even so setting a learning center for students to just go and explore whenever their feel like it…(Linda, Grade 3, Feb. 19, 2015)</td>
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<tr>
<td></td>
<td>So providing all those choices to the students and having them chose a center of a choice…(Linda, Grade 3, Feb. 19, 2015)</td>
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<td></td>
<td>Ur…you are facilitating, you are preparing them with the concepts, providing them with words, showing them visuals, it could be anywhere form pictures to videos on a specific topic on science. Ur:. providing whatever is necessary for the children or students to explore, let them go on explore, even gaining interests to explore something related to science,</td>
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<td></td>
<td>I give a lot of the students a different, well various types of magnet. (Linda, Grade 3, Feb. 19, 2015)</td>
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</table>

We are the promoters, you know promoters connecting children’s ideas together, we’re promoting their ideas to the community, we are challenging, ur we are listening so that becoming aware of some of their misconceptions we can help. We are designers and ultimately, that fits into what the students’ role which is to be as much as to be appropriate and to be part of the design too, because the community’s interest will help to shape the directions of inquiry and the questions and what we try to do is find a way that all students are contributors so the contribution may look very different but everybody can contribute because it’s about ideas and everyone has an idea and can make observations and contribute.  
I just think also the role of the teacher is to be seeing how the inquiry is supporting all the growth of the child. (Anna, Kindergarten, Feb. 19, 2015)  
That the teacher is holding a very strong thread in their mind of what the trade trajectory should or could look like.  
But we are not being flexible about that. We are learning the children move where they might be going. But we are actually holding a big picture of what the learning would or should be happening, where the learning would or should be happening. (Anna, Kindergarten, Feb. 19, 2015)
We are really open and flexible so that what we do today will do determine what we do tomorrow. We don’t know what tomorrow is going to look like until today has happened. So we might go into a few ideas and see what happens. And then we will go from there so we are definitely in charge. I think sometimes the people think that the children are just, you know, anything goes, the kids are controlling things, it really isn’t a negotiate process, the teacher has a strong role. (Anna, Kindergarten, Feb. 19, 2015)

We have children working on many things, but everybody knows why we are doing, what we are doing. So, in terms of advancing knowledge. (Anna, Kindergarten, Feb. 19, 2015)

…. but what our role is coming in and at that whole time, we are thinking about the children, are they paying attention to it, are they making key observations, are they extrapolate from the observations, are they bringing in past experience, are they listening to what other children are saying…(Anna, Kindergarten, Feb. 19, 2015)

…So having that opportunity for kids to bring that up… …While some students said what if we drop paper, well I think paper would be different. So we get paper out and before we drop the paper, what do you think would happen? (Anna, Kindergarten, Feb. 19, 2015)

I believe it’s up to us, we need to provide whatever it is necessary for the students whether it could be a hands-on learning, you know bring in objects into the classroom, doing an experimentation with a large or a small group exploring things on their own...(Linda, Grade 3, Feb. 19, 2015)

…but as a teacher providing you know the appropriate questions, for instance, “what object do you think will sink or float?” so asking them to predict or make a hypothesis at first and then perform the experimentation. (Linda, Grade 3, Feb. 19, 2015)

We are going to write down what you noticed, what one thing that you noticed is, and then children can pick one thing and they also draw it. So there are lots of different ways for them to communicate that. (Anna, Kindergarten, Feb. 19, 2015)

<table>
<thead>
<tr>
<th>Teachers’ implementations of inquiry</th>
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</thead>
<tbody>
<tr>
<td><strong>Content</strong></td>
</tr>
<tr>
<td>Specific references to importance of teaching/learning content (referring only to canonical type of knowledge)</td>
</tr>
<tr>
<td>…and even paying attention to ur…you know the facts that the existence in science…</td>
</tr>
<tr>
<td>…and magnified glasses to observe all the different kinds of materials or rocks, or leaves, or whatever materials were available.</td>
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<tr>
<td>They were able to have a better outstanding and a theory behind why magnets act the way that they do.</td>
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<tr>
<td>To learn specifically more about magnets.</td>
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<td>That was part of the curriculum that was one of one of the primary reason but then afterwards, it became more of an interest in mine, and became an exploration, at first, their primary knowledge of magnets were not vest, but slowly as we build on and slowly as the student investigate about the magnets, they were able to form maybe make a deductive conclusion whether their theory or whether their prediction conclusion was correct or incorrect they</td>
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were able to observe what they saw through the experimentation, and therefore form a conclusion about what they thought about magnets…(Linda, Grade 3, Feb. 19, 2015)

We do have a big idea where we might go. But we are really open and flexible said so that what we do today will do determine what we do tomorrow. We don’t know what tomorrow is going to look like until today has happened. (Anna, Kindergarten, Feb. 19, 2015)

I think we are inspired by the curriculum but not limited by the curriculum expectations. (Anna, Kindergarten, Feb. 19, 2015)

So we were working on astronomy yesterday and the children from JK/SK we were exploring how gravity works in space and on earth. So obviously it is very difficult to find out and have an experiment working in the space, so we can look at how gravity work on earth…(Anna, Kindergarten, Feb. 19, 2015)

…We were using ramps, having things roll or slide down from the ramp, we are trying to get the idea of friction, so the same way, you know, we were moving into the idea of air resistance. (Anna, Kindergarten, Feb. 19, 2015)

…so bringing in information, bringing in vocabulary, bringing in the book. (Anna, Kindergarten, Feb. 19, 2015)

…It’s going to give us the vocabulary, we don’t want to make it up on our own. We are not just going to be able to pull it out through the scenario. Let’s bring it in at certain time…(Anna, Kindergarten, Feb. 19, 2015)

<table>
<thead>
<tr>
<th>Process</th>
<th>Wanting students to learn something about how to do science, e.g., learn how to experiment, measure, record</th>
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<td>…and hopefully to share what they’ve made after they made it, to talk about what they’ve done. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td>…I think it’s allowing the children to explore and use a variety of materials. And to learn about which materials glue better together, what it gear together, what paint stick to, what paint doesn’t stick to. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td></td>
<td>The primary learning goal of the lesson is to explore a variety of materials to make a structure to share with the class. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td>…And so like, one week they build with straws and one week they will build with pipe cleaners and that lead to like a big project where they got to build something large. (Mary, Kindergarten, Dec. 04, 2014)</td>
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<td></td>
<td>…. I think they’ve learned which materials work better, what’s the better fastener. Like if you glue it with white glue it sticks better than if you do it with a glue stick or a tape. I think they’ve learned a lot about putting a U cap, put something heavy on top of something light it will fall down. I think they really learned a lot. (Mary, Kindergarten, Dec. 04, 2014)</td>
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If the students are a little bit older, they can follow what do you call it…the scientific order? The things, you know, predicting the first, and observing, doing the experimentation and then write up the conclusion. That would be the role of students. (Linda, Grade 3, Feb. 19, 2015)

I think I reached the goals in a sense that they were able to learn how to make hypothesis how to observe, how to make a conclusion. So using that aspects into other scientific inquiry, so for example it could be rocks and minerals, or it could be tings about simple machines, so using that aspect of hypothesising of making observations or making conclusions taking along to another topic and so forth. Yeah, so I think it was effective. (Linda, Grade 3, Feb. 19, 2015)

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<th>Problem solving</th>
<th>engaging students with challenging questions and solving problems</th>
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<td>So we continued from there, and the idea was try that with anything that we could drop would go straight down. While some students said what if we drop paper, well I think paper would be different. So we get paper out and before we drop the paper, what do you think would happen? They all wash their hands back and forth, they cannot articulate: well it is going to flow, it’s going to bend… so we do it, so why do you think that happened, and they said because it is so light. Oh because it is so light. Then let’s begin with the baby light object. So you drop those two things and it still fell down soothing. Because it is light, so here is another piece of paper, and these two pieces of paper are the same, so I am going to crumple this one up, is this heavier now or is this still the same piece of paper? it is just a different shape, but what’s</td>
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going to happen now if I drop them, so they predicted that one is going to drop down, why this one is going to drop down? Because it is not flat, it is not spread out. So the whole time challenging them, challenging with their preconceptions challenging their misconceptions, but also building on their experience, you can see how excited they will be getting that because they knew what was going to happen as soon as they saw the objects even before they saw it happens. (Anna, Kindergarten, Feb. 19, 2015)

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<tr>
<th>Affectivity</th>
<th>Fun, enjoyment, excitement, develop interest in science (general), sense of accomplishment</th>
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|             | …I think their role is to stay on task to have fun.  
|             | …Just really allowing them to explore a variety of materials and use their imagination and creativity. (Mary, Kindergarten, Dec. 04, 2014)  
|             | I found that my particular class loves to build. So the whole thing started out that they were all fighting over the Lego. And they all want to build with Lego. (Mary, Kindergarten, Dec. 04, 2014)  
|             | …because it’s all ties into motivation and the kids are more interested in what they are doing. And the kids enjoy doing it and they want to. This whole building in all took off because my class loves to build. And they just expanded and expanded because we based on the kids interests. (Mary, Kindergarten, Dec. 04, 2014)  
|             | …They have built robots, they’ve built castles, they’ve built airplanes, they’ve built trucks, they’ve built cars, um, and they built bird houses because we found a little few toy birds. Several kids built two houses for the bird to feed in. Whatever they decide to…(Mary, Kindergarten, Dec. 04, 2014)  
|             | …sometimes we sway them because all the girls wanted to make castles and it’s getting a little boring  
|             | They all want to know when it’s their turn to go next and the kids are loving it. I think it’s great because they are very excited and it’s all about motivation. (Mary, Kindergarten, Dec. 04, 2014)  
|             | I think inquiry-based learning is all about having the children or having the students gain an interest in something related to science. Exploration, having that curiosity that drives to learn, In kindergarten, that would be simply exploration, gaining that interests, and curiosity to go further and beyond….it really wows the kids, it seems that everyone in the entire class was amazed and therefore, they were so much more interested in the learning about magnets…students were able to put their curiosity into the task. (Linda, Grade 3, Feb. 19, 2015)  
|             | …just you know, how fun magnets can be and these are just very easy concept but to these kids, they were like the out of this world concept to them. (Linda, Grade 3, Feb. 19, 2015)  
| Other | Reading, writing, or other non-science related purposes |
|         | So the children know there is words around like Lego, straws, pipe cleaners. They are able to copy and write the materials themselves. We have them write what they have made and plan to make. And then it allows us to see their pictures because it’s amazing even some of these senior kindergarten kids, sometimes the odd kids could even draw in perceptive, it’s amazing. (Mary, Kindergarten, Dec. 04, 2014)  
|         | So it really tie in a lot of language, um, a lot of language bullets too because the children are spending a lot of time, writing, talking, reading, writing. So it’s not just science based, it’s really binging in other course subject. (Mary, Kindergarten, Dec. 04, 2014)  
|         | …doing an experimentation with a large or a small group exploring things on their own, even so setting a learning center for students to just go and explore whenever their feel like it, but again integrating language and math at the same time into the science. (Linda, Grade 3, Feb. 19, 2015)  
|         | And…and to tie with that, I incorporative art as well and always language into it…(Linda, Grade 3, Feb. 19, 2015)  
|         | so we’re looking at the growth of their understanding within that the content of that inquiry, but we are also looking at how that inquiry is supporting perhaps their understanding in math, how they are able to use other areas |
of academic or intellectual skill growth to support what they’re learning in vice versa, so we do want to see that inquiry is also embedded within writing that they are doing, different ways of communicating whether it’s oral or through a PowerPoint or whatever, we are looking at their growth in all the domains that would be what we want to see it happens. (Anna, Kindergarten, Feb. 19, 2015)

| Implementation Ability/Challenges | Challenges of classroom management | I think in the class room it gets too loud because they are having fun, they are all excited. And the noise level is too loud. That a huge challenge. (Mary, Kindergarten, Dec. 04, 2014)  
…27 kindergartens in a very small room can be very loud. (Mary, Kindergarten, Dec. 04, 2014)  
I thought my centers did run smoothly, but I think I would tweak a little bit by just being more organised and having students probably doing a project afterwards. (Linda, Grade 3, Feb. 19, 2015) |
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<td>Paring</td>
<td>Challenges of paring students up.</td>
<td>…I think some of the challenges in my class have been the pairings. Cause sometime you got the very strong child with the very weak child. The strong child will try and make all the decisions. So it's the cooperative aspect that could be hard because they are doing in the groups deal. So I think that is the most challenging thing is pairing kids the right partner and having them work well together. Not having one child take over. (Mary, Kindergarten, Dec. 04, 2014)</td>
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| Material | Challenges of getting materials. | Also it would be nice to have more materials but I have been very lucky that I am, I have a lot of friends have kids and give us all the old kids’ toys. So I have tons of Legos, and blocks and pipe cleaners and straws. (Mary, Kindergarten, Dec. 04, 2014)  
It would be nice to have other materials like straws with ticks. As we go on, it would be nice to have more and more materials. (Mary, Kindergarten, Dec. 04, 2014)  
…Maybe improve more material, provide more materials than what we had in class. Sometimes the painting is hard because some of the boxes are eliminated and the paint doesn’t stick. So maybe some of the boxes needed to be primed before they could be painted. (Mary, Kindergarten, Dec. 04, 2014)  
The materials. Finding the materials that would be a little bit challenge. But I also give my responsibility to my students. That kind of helped, probably organising materials sorting the materials so that the centers could run a little bit more smoothly. (Linda, Grade 3, Feb. 19, 2015)  
Probably giving them more opportunities to explore other classes and see what other classes were doing, but in terms of challenges, I think lots of them are the materials challenges, combining the materials, collecting materials... (Linda, Grade 3, Feb. 19, 2015) |
| Understanding of scientific content | Challenges of understanding the scientific content. | because you never know fully you know, how deeply the children are going to go, so it means as a teacher, that I constantly doing my own work to figure out what is this concept that we are trying to understand and one has to feel comfortable with that state, that doesn’t mean that I am being irresponsible that, ur you know “the children will know more than I will”. We are call to deepen our own understanding and identify our misconceptions along the way. (Anna, Kindergarten, Feb. 19, 2015) |