SUPPORTING METACOGNITIVE DEVELOPMENT IN EARLY SCIENCE EDUCATION: EXPLORING ELEMENTARY TEACHERS' BELIEFS AND PRACTICES IN METACOGNITION

by

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Abstract

Metacognition is the understanding and control of cognitive processes. Students with high levels of metacognition achieve greater academic success. The purpose of this mixed-methods study was to examine elementary teachers’ beliefs about metacognition and integration of metacognitive practices in science. Forty-four teachers were recruited through professional networks to complete a questionnaire containing open-ended questions (n = 44) and Likert-type items (n = 41). Five respondents were selected to complete semi-structured interviews informed by the questionnaire. The selected interview participants had a minimum of three years teaching experience and demonstrated a conceptual understanding of metacognition.

Statistical tests (Pearson correlation, t-tests, and multiple regression) on quantitative data and thematic analysis of qualitative data indicated that teachers largely understood metacognition but had some gaps in their understanding. Participants’ reported actions (teaching practices) and beliefs differed according to their years of experience but not gender. Hierarchical multiple regression demonstrated that the first block of gender and experience was not a significant predictor of teachers' metacognitive actions, although experience was a significant predictor by itself. Experience was not a significant predictor once teachers' beliefs were added.

The majority of participants indicated that metacognition was indeed appropriate for elementary students. Participants consistently reiterated that students’ metacognition developed with practice, but required explicit instruction. A lack of consensus remained around the domain specificity of metacognition. More specifically, the majority of
questionnaire respondents indicated that metacognitive strategies could not be used across subject domains, whereas all interviewees indicated that they used strategies across subjects. Metacognition was integrated frequently into Ontario elementary classrooms; however, metacognition was integrated less frequently in science lessons. Lastly, participants used a variety of techniques to integrate metacognition into their classrooms. Implications for practice include the need for more professional development aimed at integrating metacognition into science lessons at both the Primary and Junior levels. Further, teachers could benefit from additional clarification on the three main components of metacognition and the need to integrate all three to successfully develop students’ metacognition.
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Chapter 1:
Introduction

I first became interested in metacognition while I was completing my Bachelor of Education degree. Metacognition is the understanding, awareness, and control of one’s cognitive processes (Baker, 2010; Papleontiou-Louca, 2003; Thomas, 2011). As a teacher candidate, I kept hearing faculty members refer to the importance of metacognition, yet they never stopped to actually explain what it meant to be ‘metacognitive.’ The consistent reference to this unfamiliar term led me to research this concept outside of my course work. As I began to review the extensive literature on the importance of metacognition, I wondered how many other teacher candidates were unfamiliar with this concept that is crucial for student learning. I remember asking some of my peers about their knowledge of metacognition and found that they had little to no understanding, despite it being mentioned consistently in our classes. I found the lack of understanding surrounding metacognition quite troublesome and decided to explore practicing teachers’ thoughts on metacognitive thinking.

I chose in-service teachers because I believe that metacognitive practices are examples of best teaching practices that should be integrated into elementary classrooms. The science context arose because I noticed throughout my teaching placements that many teachers had varying confidence levels in their delivery of the curriculum. In particular, many teachers were not as confident teaching elementary science compared to literacy or math. These observations led me to consider the possibility that maybe teachers are not as comfortable integrating metacognition into their elementary science
lessons. Whether or not this hypothesis is true, it was interesting to gain a better understanding of teachers’ perspectives on metacognition within an elementary science education context.

In today’s society, students have many demands throughout their educational journeys, with learning an arduous process for students of all ages. Students are required to know extensive curriculum material in a relatively short amount of time. As a result of focusing upon content knowledge, students may not understand how to learn effectively. It is important that students know how to learn and regulate their learning so that they can continue to learn for life (Papleontiou-Louca, 2003). Students need to understand themselves as learners, the learning process, and their thinking; essentially they need to be metacognitive (Wilson & Bai, 2010).

**Purpose and Research Questions**

Currently, we have little knowledge of what in-service Ontario teachers think about metacognition. Therefore, the purpose of this study was to examine Ontario elementary teachers’ perspectives on metacognition within an elementary science education context and their beliefs about elementary students’ abilities to be metacognitive. Teachers’ perspectives may include their beliefs, concerns, assumptions, understandings, and misconceptions about metacognition. To better understand teachers’ perspectives on metacognition, a mixed-methods approach was used. The results from this study could be used to inform the design of professional development opportunities for teachers, the development of metacognition resources, and the nature of pre-service teacher education.
The following research questions were addressed in this study:

1. How do Ontario elementary teachers conceptualize metacognition?
   a) What assumptions do participants have about metacognition?
   b) What misconceptions do participants hold about metacognition?
2. What is the relationship between metacognitive beliefs and actions in elementary teachers?
3. How do Ontario teachers integrate metacognition into their elementary science lessons?
   a) Describe Ontario teachers’ experiences with integrating metacognition.
4. What facilitates and hinders teachers’ integration of metacognition into elementary science lessons?
   a) What resources help teachers integrate metacognition into elementary science lessons?
   b) What are some perceived barriers or difficulties that elementary teachers report as impacting their integration of metacognition into science?

**Rationale for Proposed Study**

Metacognition has traditionally been studied in relation to reading comprehension and literacy skills, with surprisingly little extension across other subjects, despite the well-documented importance of metacognition (Carrell, Gajduske, & Wise, 1998; Pressley, 2002; Wenden, 1998). Furthermore, research has traditionally focused upon metacognition in higher education and older students. Due to the increased interest in
studying metacognition within a science context, Zohar and Barzilai (2013) conducted a review of literature to determine current trends but also future directions with respect to metacognition in this context. After synthesizing research trends in this field, an area identified as requiring greater examination was teachers’ perspectives on metacognition. More specifically, a greater understanding of what teachers know about metacognition, and their beliefs about young children’s abilities to be metacognitive while learning science content needed to be examined. These identified gaps in the research align with the research questions that I investigated. Before metacognition can be implemented across subjects in Ontario schools, more knowledge about teachers’ perspectives on metacognition was required. In particular, it was important to examine the perspectives that Ontario teachers had surrounding metacognition in elementary science contexts (Thomas, 2011; Zohar & Barzilai, 2013).

**Ontario Elementary Education Context**

In Ontario, children begin elementary school at age 4 as they enter Junior Kindergarten, finishing elementary school at Grade 6 (or sometimes Grade 8). Literacy and mathematics are prioritized with a mandated 100 minutes a day for literacy and minimum of 60 minutes a day for mathematics. Other subjects – science and technology, the arts, health and physical education, social studies, and French as a second language – must be taught around the literacy and numeracy blocks. With this system, students may not receive daily instruction in science, which may add challenges for teachers when they are working to integrate metacognition into their elementary science lessons. There is also a set curriculum used in Ontario elementary classrooms as mandated by the Ontario
Ministry of Education. All teachers who participated in this study were certified by the Ontario College of Teachers for either part-time or full-time employment in Ontario elementary schools. This certification is required to teach in the public system within Ontario, either in the Primary/Junior streams (elementary) or Intermediate/Senior streams (secondary).

Outline of Thesis

This thesis is composed of five chapters used to thoroughly document the conducted study. Initially, Chapter 1 situated the reader within the Ontario education context and the research questions used to guide this study. Chapter 2 outlines the related literature in the field used to inform the methodological development of this study. The research methods are outlined for both the quantitative and qualitative data sources as a sequential explanatory mixed-methods design (Johnson & Onwuegbuzie, 2004) in Chapter 3. The results are presented in Chapter 4, organized according to the four research questions. Lastly, Chapter 5 discusses these results, suggests directions for future research, and proposes educational implications for supporting elementary teachers’ metacognitive integration practices further.
Defining Metacognition

A universal definition for metacognition and its composition does not exist (Larkin, 2006). Despite not having a universal definition, there are characteristics and components of metacognition that are consistently cited across the field. These characteristics of metacognition are outlined and used to guide the proposed research study. For this study, metacognition is defined as the understanding, awareness, and control of one’s cognitive processes (Baker, 2010; Papleontiou-Louca, 2003). As a result of diverse and inconsistent definitions of metacognition, researchers also disagree with the most appropriate ways to measure metacognition. Limitations for all measurement tools used in this study are outlined but are unfortunately unavoidable given the lack of coherent conceptualizations (Schraw & Impara, 2000).

Flavell (2002) is cited most often when discussing metacognition, as he is a pioneer in the field and has encouraged other researchers to expand upon his foundational conceptualization of metacognition. Flavell’s work is used consistently to form conceptual frameworks in previous studies examining metacognition. His most recent work includes revisions from fellow researchers exploring metacognition, as the conceptualizations of the three main metacognitive concepts (metacognitive knowledge, metacognitive regulation, and metacognitive experiences) continue to grow (Flavell,
When Flavell first conceptualized metacognition, he believed that it consisted of two main components, with a third component added later. The two original components of metacognition, according to Flavell and his colleagues (Flavell, 1979; Flavell et al., 2002), were “metacognitive knowledge” (metacognitive awareness) and “metacognitive regulation.” A third component of metacognition was added later and termed “metacognitive experiences.” Although Flavell acknowledged this third component of metacognition in his publications, he emphasized the importance and study of the other two aspects. Building upon Flavell’s (1979) conceptualization of metacognition, Efklides (2002; 2008) viewed metacognition as having three main components: metacognitive knowledge, metacognitive skills, and metacognitive experiences. All three components were deemed to be crucial for successful learning (Efklides, 2002; 2008). Figure 1 summarizes the conceptual framework for metacognition.
**Metacognition:**
Understanding, control, and awareness of one’s cognitive processes (Baker, 2010; Papleontiou-Louca, 2003; Thomas, 2011)

**Metacognitive Knowledge:**
Thoughts and beliefs about one’s cognitive capabilities (Flavell, 1979).
Can be in relation to:
- person (self)
- task
- strategies
Can be broken down into:
Declarative- “Knowing that”
Procedural- “Knowing how”
Conditional- “Knowing when”

**Metacognitive Experiences:**
Affective experiences (judgments and feelings) that people have about their learning and knowledge of their learning (Ben-David & Orion, 2013; Efklides, 2006).
Feelings of:
- familiarity
- difficulty
- confidence/satisfaction

**Metacognitive Regulation:**
Monitoring and control of one’s learning (Flavell, 1979)
Metacognitive regulation contains three main components:
- planning
- monitoring
- evaluating

Modified from Efklides, 2006

**Figure 1: Conceptual Framework for Metacognition**
Components of Metacognition

There are overlapping features across metacognitive knowledge, metacognitive regulation, and metacognitive experiences. Information is used from one or more of the metacognitive components to inform ongoing and future learning processes. However, it is most efficient to develop all three components because they consistently enhance each other (Papleontiou-Louca, 2003). For example, students’ metacognitive regulation is not properly developed or utilized effectively unless students have the more general understanding of how they think and learn. Metacognitive experiences can be used to inform the use of metacognitive strategies. Students can revise the strategies used when they have feelings of uncertainty or confusion (Papleontiou-Louca, 2003).

Metacognitive knowledge (MK) includes thoughts and beliefs about cognitive capabilities. According to Flavell (1979), there are three types of categories to which these thoughts and beliefs may be in relation: yourself (person category), task, or strategies. Metacognitive knowledge is general knowledge about an individual’s cognition (Efklides, 2006; Flavell, 1979). This component of metacognition may develop later than metacognitive experiences or metacognitive regulation (Brown, 1987). The thoughts and beliefs in the person category are traditionally in relation to individual cognitive processes, although Flavell extended this category to relate to the cognitive processes of other individuals. More specifically, these are the thoughts about one’s strengths and weaknesses in relation to how one learns but also processes information (Flavell, 1979). An example of thoughts or beliefs about oneself (person category) would be that an individual memorizes content effectively through repetition and rehearsal.
Metacognitive knowledge in relation to tasks is when details about the task influence how the learner manages the information (Flavell, 1979). For example, when a student believes that it is easier to answer comprehension questions after reading a text in literacy than in science, metacognitive knowledge in relation to tasks is being shown. Metacognitive knowledge about strategies is the understanding one has about appropriate strategies and how they can be used to achieve one’s learning goals, for example, when individuals believe that it helps them to better understand new content by teaching it to peers (Flavell, 1979).

Metacognitive knowledge was revised from Flavell’s (1979) framework and broken down further into three types: declarative, procedural, and conditional knowledge (Brown, 1987; Jacobs & Paris, 1987). These components of MK are directly related to the initial categories devised by Flavell. Declarative knowledge is fact-based and objective knowledge that one has acquired (“knowing that”; Schraw & Moshman, 1995). Declarative knowledge within a metacognitive context is what persons know about themselves as learners, including their strengths and weaknesses. Procedural knowledge is used to perform tasks; it is the knowledge and understanding of how to execute actions to solve a problem or achieve a desired result (Schraw & Moshman, 1995). In relation to metacognition, procedural knowledge involves knowledge of the steps that can be taken to learn; “knowing how” (Schraw, 1998). Conditional knowledge is the understanding of when and why to use the other two types of knowledge (Schraw & Moshman, 1995). In terms of metacognition, conditional knowledge is the understanding and application of strategies to enhance learning (Schunk & Zimmerman, 1994, 1998).
Metacognitive regulation (MR) includes the monitoring and control of learning (Flavell, 1979). Metacognitive skills (a component of MR) are used by the learner to allocate the time and effort necessary to complete a task. Regulation of one’s learning also involves setting goals, planning in advance how to meet those goals, and assessing the effectiveness of one’s progress throughout the learning process. Metacognitive regulation is the more active, in-the-moment component of metacognition (Efklides, 2006).

Metacognitive regulation contains three main components: planning, monitoring, and evaluating. These are essential skills that students must be able to implement effectively before being able to regulate their own learning. Planning requires students to set goals, choose suitable strategies, and predict possible learning outcomes. Monitoring is the ability to check the progress of one’s learning (understanding) and one’s execution of a task (Schraw & Moshman, 1995; Whitebread et al., 2009). This skill traditionally is very slow to develop in children and requires explicit instruction to improve (Delclos & Harrington, 1991; Glenberg, Sanocki, Epstein, & Morris, 1987; Pressley & Ghatala, 1990). Evaluation is the process whereby students review their learning, often considering their goals, and reflecting upon whether or not they met these goals (Schraw & Moshman, 1995, Whitebread et al., 2009).

A third component of metacognition is termed metacognitive experiences, which includes the affective experiences (judgments and feelings) that people have about their learning (Ben-David & Orion, 2013; Efklides, 2006). Individuals’ estimations about their learning, knowledge, and progress are part of metacognitive experiences (ME). Feelings
of familiarity, difficulty, confidence, and satisfaction are aspects of metacognitive experiences (Ben-David & Orion, 2013; Efklides, 2006). Flavell (1979) made a connection between metacognitive experiences and young children. He emphasized the importance of teaching children how to interpret these affective experiences that relate to their learning (Flavell, 1987; Georghiades, 2004). For example, a child may be completing a multiple choice question on a science test and have a sense of uncertainty about an answer that he or she just circled. This feeling of uncertainty may lead the child to seek clarification of this material after submitting a best guess on that question, or it could result in the child changing the answer to one about which he or she feels more confident. These feelings about their learning experiences can lead children to revise goals during the learning process or may affect the decisions that they make about their learning. When studying for a test, students who know how to understand their metacognitive experiences can use these experiences to inform them of their progress while studying because they have a sense of what they do and do not understand content wise (Papleontiou-Louca, 2003).

**Literature Review**

Metacognition is important to integrate into classrooms because it tends to lead to greater academic success (Sternberg, 1998). Metacognitive and self-regulated learning behaviours are closely related and need to be developed together for students to become effective learners. To become self-regulated learners, students must control and monitor their learning using metacognitive regulation. Self-regulated learning happens when individuals are able to independently plan, monitor, and assess (evaluate) their learning
(Zimmerman, 2002). Students with strong metacognitive abilities tend to have more successful learning outcomes when compared to students without strong metacognitive abilities (Sternberg, 1998). Metacognitive students are aware of their learning and can regulate their own learning, making necessary changes to attain their goals (Griffith & Ruan, 2005). These students understand how to learn, and are successful because they know what they have to do to acquire, retain, and use new information (Wilson & Bai, 2010). However, metacognitive skills are not innate in nature; they must be learned and further developed (White & Frederiksen, 1998). Having these skills results in more efficient and productive learners. All of the three components of metacognition are beneficial for students. Therefore, these components should be developed from a young age.

**Benefits of Metacognitive Components**

The three types of metacognitive knowledge (declarative, procedural, and conditional) are related to better learning outcomes as they enable students to monitor, plan, and evaluate their learning, making changes as needed. The development of declarative knowledge is important for self-assessment (Shraw, 1998; Schraw, Crippen, & Hartley, 2006). Students who possess strong declarative knowledge are able to utilize their strengths and address their weaknesses during academic performance. A well-developed procedural knowledge leads to more efficient learning because students know how to use helpful strategies in appropriate sequences, and they have many different strategies that can be used in a variety of problem-solving contexts (Shraw, 1998; Schraw, Crippen, & Hartley, 2006). Enriched conditional knowledge allows for students
to monitor their learning progress and implement strategies appropriate for context-specific situations (Shraw, 1998; Schraw, Crippen, & Hartley, 2006). Despite the benefits of having well-developed declarative and procedural knowledge, these two types of knowledge are not enough to help learners adapt. To be flexible while learning, students must have accurate knowledge about the required skills and themselves as learners (Alexander, 2003; Schunk & Zimmerman, 2006).

Metacognitive regulation can be fairly unstable (it can change) and is not dependent upon age; therefore, it can be developed in young children (Brown, 1987; Whitebread, 1999). Students can learn to improve their metacognitive regulation by developing metacognitive strategies (Babkie & Provost, 2002). However, older students tend to have a greater understanding of their memory capabilities and limitations than do younger students. They also tend to have more experience with regulating their learning and applying appropriate strategies; therefore, they are more proficient with planning the use of strategies (Torgeson, 1977). As a result, teachers need to consistently model the use of metacognitive strategies for younger students, while reminding them of any application conditions; such as when and how the strategies should be used (Driscoll, 1994). The development of metacognitive regulation allows students to control and regulate their learning, leading to more flexible learning environments (Shraw, 1998; Schraw, Crippen, & Hartley, 2006). This type of learning environment is beneficial for students because they can direct their learning through planning how they are going to complete a task, organizing appropriate strategies, checking their progress throughout, and determining how effective they were at completing tasks.
ME was added to broaden the conceptualization of metacognition to reflect the authentic school and classroom context (Efklides, 2006). These affective feelings are significant because they can persuade students to manipulate (change or revise) current goals or form new ones. Metacognitive experiences can lead students to select and use effective strategies to reach their learning goals (Nelson, 1992). This last component of metacognition is frequently left out if researchers are not able to examine all components effectively, and is therefore relatively under-researched. Teachers should understand and recognize the significance of metacognitive experiences because these experiences can be quite helpful for students when they learn how to interpret their affective experiences effectively (Efklides, 2006). It would be beneficial to know what students are thinking during their learning, such as when they have feelings of difficulty, satisfaction, or confidence. If students are having feelings of difficulty while answering questions on a unit test, following the test, teachers could review methods for studying the content and teach possible strategies for test-taking.

Students who think metacognitively use their previous knowledge of successful and unsuccessful learning attempts (metacognitive experiences) to inform their future learning (Papleontiou-Louca, 2003). These students have to be able to reflect upon why they were successful or unsuccessful in various situations, while utilizing this information to effectively regulate their future performances in learning tasks. Students with well-developed metacognition have the ability to recognize strategies that work well for them and know to use them again to achieve their learning goals. This research demonstrates that metacognition is important and needs to be integrated into instructional practices
with all three components leading to more efficient academic outcomes. Therefore, teachers need to integrate metacognition into their teaching practices to increase the quality of students’ learning and thinking about their learning (Brown, 1994; Brown & Palincsar, 1989; Cross & Paris, 1988; Thomas & McRobbie, 2001; Thomas, 2011).

**Metacognitive Teaching Practices**

The integration of metacognitive instruction in elementary science education would likely vary across grade levels, classrooms, and especially across teachers. However, there are some instructional practices that have successfully improved students’ metacognition that are consistently used (Papleontiou-Louca, 2003). For example, the think-aloud approach has proven to be quite effective and has been recommended for consistent use to help students follow the teacher’s thinking, develop problem solving techniques, plan goals, and use effective strategies. Thinking aloud promotes students’ development of a vocabulary to describe their thinking, which they can understand and use themselves (Brown, 1987; Blakey & Spence, 1990; Garner, 1987).

Another effective and influential technique for increasing students’ metacognitive thinking is explicit modelling by the teacher. Teachers explicitly model when they directly demonstrate the use of a specific skill or approach. Teachers can demonstrate their use of metacognitive strategies, describe their thinking, plan their goals out loud, suggest problem solving methods, and show students how they can work through their thinking. Thinking aloud is different to explicit modelling because it only involves an individual’s thought processes whereas explicit modelling can include the demonstration
of strategy use, problem solving, and specific skills without verbalizing an individual’s thoughts (Papleontiou-Louca, 2003).

Additionally, students can develop their metacognitive thinking by describing and demonstrating their problem solving skills to other students. Students work in pairs or small groups where they take turns solving a problem, while the other students ask questions about the approach being used. This technique encourages the use of effective questioning, especially when the teacher models effective questioning throughout science lessons (Blakey & Spence, 1990; Charalambous, 1999; Papleontiou-Louca, 2003). These three approaches are effective in helping improve students’ metacognitive thinking because thinking and learning are made transparent for students to follow.

Teachers should be sure that they consistently debrief their thinking and students’ thinking throughout lessons. A three-part approach has been suggested whereby the teacher reviews the task with the students while discussing the strategies used and the feelings that students had during that task. Next the teacher guides the students through summarizing key ideas and recalling the different strategies used throughout the learning task. Lastly, students reflect upon whether or not they met the goals set for this task. Students should identify which strategies worked well and those that did not work well for them (Blakey & Spence, 1990). These are only some of the traditional and effective approaches that are suggested for consistent use in the classroom to develop metacognition in students. Gaining a better understanding of teachers’ perspectives on metacognition should help with further integration of metacognition and metacognitive teaching practices in the classroom.
Teachers’ Perspectives on Metacognition

In-service teachers’ perspectives on metacognition have not been thoroughly studied, especially within elementary science contexts. The following studies provide insight into this area of research. Ben-David and Orion (2013) documented 44 elementary science teachers’ perspectives surrounding the integration of metacognition into science education in Israel. The participants attended a professional development program and engaged in metacognitive learning. Most of the participants had negative and/or incomplete views toward the integration of metacognition into elementary science education (e.g., metacognition is only appropriate for high-achieving students; elementary students are unable to think metacognitively) before attending the program. However, following the program, participants’ views became more positive. They were amazed at how metacognition was fairly new to them. Participants reported that the metacognitive experiences component was the most important aspect for instructors trying to bridge the gap between teaching and learning. The teachers expressed interest in learning more about integrating metacognition. These results indicate that teachers’ perspectives surrounding metacognition are not necessarily fixed. The results highlight misconceptions of metacognition that would be harmful to students (Ben-David & Orion, 2013). The current study investigated if Ontario teachers had similar beliefs and misconceptions about metacognition.

Wilson and Bai (2010) similarly examined the relationship among teachers’ metacognitive knowledge, their pedagogical understandings, and their perceptions of how to teach students to be metacognitive. One hundred and five M.Ed. students in the United
States completed a researcher-developed survey online. Their survey measured participants’ thoughts about their metacognitive understanding and pedagogical understanding of metacognition. The survey consisted of demographic questions, two open-ended questions, and 20 Likert-type questions, where the participants rated their agreement with the question from 1 (strongly disagree) to 4 (strongly agree). The researchers found a significant relationship between metacognitive knowledge and pedagogical understanding of metacognition for the participants, where the former directly impacted the latter. The participants demonstrated that a rich understanding of metacognition was necessary to help students develop their metacognition. It was consistently mentioned that metacognition was an active process that required explicit instruction/demonstration as well as practice. This study emphasized the importance of teachers having a comprehensive understanding of metacognition and metacognitive thinking strategies to improve students’ metacognitive abilities. The survey used in this study collected both quantitative and qualitative data and was used as a model when creating the questionnaire for the present study. The inclusion of open-ended questions allowed the participants to describe their knowledge and understanding of metacognition in their own words.

Teachers seem to have misconceptions about which students are capable of developing higher-order thinking skills (metacognition). In a study conducted by Zohar, Degani, and Vaaknin (2001), semi-structured interviews indicated that 45% of teacher participants believed that low-achieving students were incapable of developing higher-order thinking. A consistent trend throughout the study was the belief that higher-order
thinking was more appropriate for high-achieving students rather than low-achieving students. Many of the teachers felt that low-achieving students would have a greater level of frustration when engaging in higher-order thinking tasks, therefore reinforcing the idea that these tasks were not as suitable for low-achieving students. Only 20% of the teachers felt that both high-achieving and low-achieving students were capable of effectively engaging in higher-order thinking tasks or activities. These views related to teachers’ theories of instruction and should therefore transfer into their teaching practices. This study emphasized some misconceptions that needed to be addressed before effective integration of metacognition could occur. Similarly, if Ontario teachers have beliefs such as those expressed by these participants, it is crucial that more is known about the nature of teachers’ beliefs.

Teachers directly impact students’ learning through their interpretations of what should be included in their teaching practices to ensure that student learning occurs (Aguirre & Speer, 1999; Borko & Putnam, 1996; Zohar, 2006). Teachers’ understandings surrounding the nature of learning affect their instructional practices and students’ learning outcomes (Brickhouse, 1990; Clark & Peterson, 1986; Hashweh, 1996; Shulman, 1987). Additionally, students’ capabilities to further develop their metacognition are shaped by their teachers (Paris & Paris, 2001). To help students develop their metacognition, teachers must have a thorough understanding of the concept themselves. Teachers need to believe that their students are capable of thinking metacognitively about their learning. Teachers must be able to demonstrate and support the use of metacognitive strategies appropriate for the developmental levels of their
students (Wilson & Bai, 2010). Therefore, before metacognition can be further integrated into the Ontario curriculum, a greater understanding of what teachers think about the concept must be acquired.

**General vs. Domain Specificity of Metacognition**

Another issue in the literature on metacognition lacking consensus is the extent to which the components of metacognition are general or domain-specific (Veenman, Hout-Wolters, & Afflerbach, 2006). It has been proposed that some metacognitive skills are general and can be transferred across contexts (Schraw, Dunkle, Bendixen, & Roedel, 1995; Schraw & Nietfeld, 1998; Veenman, Elshout, & Meijer, 1997; Veenman & Beishuizen, 2004; Veenman & Verheij, 2003; Veenman, Wilhelm, & Beishuizen, 2004). Certain metacognitive skills are modeled more consistently and perhaps differently within an elementary science lesson.

The majority of research on metacognition is focused upon a specific domain, mostly literacy and mathematics education, with little focus on science (Carrell, Gajduske, & Wise, 1998; Desoete & Roeyers, 2003; Kramarski & Mevarech, 2003; Pressley, 2002, Thomas, 2003; Wenden, 1998). This focus upon a specific domain would suggest that metacognitive skills are often demonstrated within a subject domain rather than modelled as transferrable skills. A review of studies examining metacognition in science education contexts demonstrates that metacognition has been studied most consistently within specific science contexts. Metacognition is not often studied generally in terms of problem solving in science or monitoring comprehension of scientific texts at either the secondary or post-secondary levels. Instead, metacognition is studied in
specific subject areas such as biology or chemistry, but has also been examined in relation to distinct scientific content such as evolution (Zohar & Barzilai, 2013).
Chapter 3:
Methodology

In this chapter, I describe the methods used to conduct this study. This description includes an overview of the mixed-methods research design, a description of procedures, and detailing of the data analysis. The initiatives taken to increase the credibility and trustworthiness of the results are interwoven throughout the chapter. As I maintained a reflexivity research journal throughout this research process, all decisions made were documented alongside issues, solutions, and personal reflections.

Mixed-Methods Research Design

A sequential explanatory mixed-methods research design was used to collect and analyze data, as it was the most suitable approach to use for answering the research questions in this study. Teachers likely have diverse beliefs and varying levels of knowledge about metacognition; therefore, neither a quantitative or qualitative approach would be adequate to understand teachers’ beliefs and understandings of metacognition at the elementary level. A primarily quantitative approach (survey research design) for the first phase of the study was used to describe the beliefs that elementary teachers in Ontario had about integrating metacognition into elementary science lessons. A qualitative approach (semi-structured interviews) was used in the second phase to describe in greater detail and depth different cases of integrating metacognition in elementary science lessons. The themes that emerged through the qualitative data represent the perspectives of the five Ontario elementary teachers who participated in this study.
Technically, there was an overlap in data collection as a result of recruitment issues where the questionnaire remained open while I was conducting the interviews. Still, the preliminary findings from the questionnaire informed the development of my interview questions and selection of Phase 2 participants, resulting in a more comprehensive and informative approach as suggested by Johnson and Onwuegbuzie (2004). The following research questions were addressed by this mixed-methods design:

1. How do Ontario elementary teachers conceptualize metacognition?
2. What is the relationship between metacognitive beliefs and actions in elementary teachers?
3. How do Ontario teachers integrate metacognition into their elementary science lessons?
4. What facilitates and hinders teachers’ integration of metacognition into elementary science lessons?

**Ethical Considerations**

This study received ethical clearance from the General Research Ethics Board (GREB) at Queen’s University. Approval for recruitment through STAO was obtained from STAO (Science Teachers’ Association of Ontario). The clearance letter for this study provided by GREB can be found in Appendix A. The Letter of Information/Consent Form is located in Appendix B. To help maintain confidentiality, all interview participants were assigned pseudonyms, while questionnaire respondents remained anonymous. Questionnaire respondents had the opportunity to provide their email to be entered into a draw. Following completion of the questionnaire, they were
redirected to a separate link where they could provide their email. There were initial technical issues where the link was not redirecting participants so they sent their email to me if they wanted to be included in the draw until the technical issues were resolved. All of their responses remained detached from their emails to help maintain confidentiality. All data remained secured through passwords I set. Any data that were shown to my committee remained anonymous or de-identified.

Participants

Full-time and part-time (in-service) elementary teachers currently teaching in Ontario public school boards were invited to complete the online questionnaire (first phase of the survey design). Forty-seven questionnaires were received in total but three were discarded as a result of ineligibility (not currently practicing teachers in Ontario), resulting in a total of 44 questionnaires. Of these 44 questionnaires only 39 were completed fully. Two incomplete questionnaires were included for statistical analyses. Therefore, there were a total of 41 participants for the Likert-type questions and 44 for the open-ended responses on the questionnaire. The majority of the respondents for the Likert-type questions identified as female (n= 31) with few identifying as male (n= 9,) and 1 respondent identifying as other. There was more of a gender balance for Phase 2 of the study with three males and two females being interviewed. Four of the five participants interviewed were experienced teachers with 12 or more years of experience. Three of the five participants had Master’s of Education degrees with high levels of content knowledge in science as a result of their Bachelor of Science degrees. All five of the interview participants had been certified through the Ontario College of Teachers for
at least 3 years and were teaching full-time in Ontario public elementary schools. Table 1 provides further details about the interviewees. All responses from the questionnaire were reported anonymously, while interviewees were assigned pseudonyms to maintain confidentiality.

Table 1: *Demographic information for interviewees*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Years of Experience</th>
<th>Education</th>
<th>Gender</th>
<th>Current Assigned Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amanda</td>
<td>24</td>
<td>B.A., B.Ed.</td>
<td>Female</td>
<td>5</td>
</tr>
<tr>
<td>David</td>
<td>15</td>
<td>B.Sc., B.Ed., M.Ed.</td>
<td>Male</td>
<td>7/8</td>
</tr>
<tr>
<td>Jacob</td>
<td>3</td>
<td>B.Sc., B.Ed., M.Ed.</td>
<td>Male</td>
<td>1/2, 6 (French Immersion)</td>
</tr>
<tr>
<td>Ben</td>
<td>18</td>
<td>M.Ed.</td>
<td>Male</td>
<td>K</td>
</tr>
<tr>
<td>Anna</td>
<td>12</td>
<td>B.Sc.</td>
<td>Female</td>
<td>7</td>
</tr>
</tbody>
</table>

**Recruitment**

Participants were initially recruited through the Science Teachers’ Association of Ontario (STAO). STAO is a non-profit organization that works to further science education in Ontario through connecting science educators with resources, and other members, while providing professional development opportunities. The link for the online questionnaire and a recruitment notice was circulated monthly through their membership email list for November, December, and January. Following this recruitment period, the numbers were still quite low for respondents so additional participants were
recruited through Facebook Teaching Groups and teaching networks through colleagues. Teachers had to be either part time or full time in Ontario, certified by OCT, and currently practicing in elementary education to be included in this study. Recruitment was cut off at the end of March with the survey closed and all interviews completed. Upon completion of the survey, participants had the opportunity to provide an email address to be entered into a draw for one of two prizes of $50 in metacognition resources or cash equivalent.

Interview participants were recruited through the questionnaire. At the end of the questionnaire, respondents were asked to provide their email if they were interested in participating in Phase 2 of the study, semi-structured interviews. Interviewees were then picked from those that indicated interest in being interviewed. Respondents’ results informed the selection of interviewees as I was looking for primarily veteran teachers from a variety of grades. I also wanted to ensure that I had some teachers with science backgrounds. I checked the data to ensure that the participants invited to participate in the interviews were indeed integrating metacognition in science and seemed to have a conceptual understanding of metacognition.

**Pilot Testing the Questionnaire Items and Interview Questions**

The questionnaire and interview questions were piloted with a focus group of doctoral students with varying backgrounds in cognition. Some of the students also had teaching experience and were therefore more representative of the in-service teaching population. I decided not to pilot with in-service teachers as I did not want to draw from my future sample when I anticipated difficulty with recruitment. Researchers in this field
have noted the difficulty with finding appropriate terminology that participants fully understand, providing one reason for piloting my questions in advance. During the focus groups, the graduate students completed the online questionnaire individually. Individuals were then given an opportunity to discuss their experiences and concerns with the questionnaire items. The interview questions were piloted during a separate meeting with the focus group at a later date. The students went through the questions and made suggestions about wording and the order of the questions. One student was unable to attend the scheduled focus group so this person met with me separately to discuss the questions in-depth. I reviewed all Likert-type items and questions that were flagged if they confused respondents, resulted in a low response rate, caused participants to consistently hesitate, or required consistent clarification (Ornstein, 2013). The survey and interview questions were also examined and approved by the supervisory committee with backgrounds in cognition, metacognition, and elementary science education.

I applied a detailed checklist “Questionnaire Appraisal System-QAS 99” (Willis & Lessler, 1999) to each Likert-type item as an indication of possible problems with the proposed survey questions. The Questionnaire Appraisal System has been designed to draw attention to characteristics and components of questions that may cause issues with collecting valid data. The checklist was applied systematically to each proposed survey question to aid me in determining issues with phrasing or structure of questions. This system is user-friendly where the researcher circles “yes” or “no” indicating whether or not each problem is present. If a “yes” is indicated, then the researcher must include justification for indicating “yes.” There are eight main steps to conduct for each question.
focusing upon identifying issues in reading the questions, instructions, clarity, assumptions, knowledge/memory, sensitivity/bias, response categories, and other. The QAS 99 has been created and modified based upon previous appraisal systems for questionnaires and provided me with clarification for each question (Willis & Lessler, 1999). The final questions used for the survey and interviews can be found in Appendix C.

**Phase 1 Data Collection: Survey**

In Phase 1, a questionnaire was developed and created through Fluid Surveys to collect demographic data (including background information related to participants’ teaching qualifications) and teachers’ perspectives of metacognition (Research Questions 1 and 2). The questionnaire contained a mixture of both original and modified questions. The modified questions came from two scales ‘Teachers’ Metacognitive Scale’ (Wilson & Bai, 2010) and ‘Self-Regulated Teacher Belief Scale’ (Lombaerts, 2009). Open-ended questions were also posed as part of the questionnaire. These open-ended questions required the participants to explain their understanding of metacognition and describe how they integrated metacognition. These questions provided participants with opportunities to explain their understanding and integration of metacognition within science contexts but also more broadly. Following the four demographic questions and seven open-ended questions, there were 26 Likert-type questions for participants to rate the extent to which they agreed with each statement ranging from 1-5 where 1 represented strongly disagree and 5 represented strongly agree.

The Teachers’ Metacognition Scale (TMS) has been tested fairly extensively for
validity and reliability measures by its authors (Wilson & Bai, 2010). Content validity for the TMS was enhanced by having expert scholars in the field of metacognition review the selected metacognitive material. Wilson and Bai (2010) performed a factor analysis to assess construct validity for the four constructs that the scale was designed to assess: pedagogical, conditional, declarative, and procedural knowledge. The measurement model accounted for 61% of the total variance. The TMS was designed because Wilson and Bai (2010) could not find the appropriate measurement tool for their survey in the existing literature. I found a similar issue when designing my own study, and therefore felt it would be most effective to build upon their survey, modifying it to better suit my study.

The Self-Regulated Learning Teacher Belief Scale was also examined for reliability and validity during the development of the scale. Multiple factor analyses were performed (both exploratory and confirmatory) to determine which items should be eliminated; the value for Cronbach’s alpha was .79. After the exploratory factor analysis suggested the elimination of some items so that those included were more general, the confirmatory factor analysis demonstrated that there was a good fit for the proposed scale (Lombaerts, 2009).

**Initiatives to Improve Questionnaire Response Rate**

Online questionnaires on average have lower response rates than paper (in-person) or mail surveys (Shih & Fan, 2008). Therefore, different initiatives were taken to increase the response rate for the questionnaire component of this study. The amount of time required to complete the questionnaire may be a deterrent for participants so the
questionnaire was designed so that it could be completed within 20-30 minutes. Also, participants may feel more compelled to complete the questionnaire if they have the possibility to obtain an incentive (Ornstein, 2013). Therefore, as previously mentioned, participants had the opportunity to be entered into a draw following completion of the questionnaire for a chance to receive metacognitive resources or cash equivalent of $50. Two prizes were provided. It is suggested that, if the researcher is persistent with participants through reminding them to complete the questionnaire, response rates will increase. Therefore, reminders were posted in the teaching groups, and I was strategic about when the survey was circulated; it seemed that weekends were better for teachers to complete the survey so a lot of reminders were posted between Friday and Sunday with direct access to the link provided in the recruitment notice (Ornstein, 2013).

**Phase 2 Data Collection: Interviews**

In the second phase of the study, five full-time elementary teachers were asked to participate in semi-structured interviews. These teachers indicated on the questionnaire an interest in and a willingness to participate in the interviews. I selected participants who had indicated a literature-supported understanding of metacognition and had three years or more experience. I made the decision to select teachers with three or more years of experience, as I made the educated supposition that they would be more comfortable with integrating metacognition. This was not necessarily justified based upon previous literature, rather it was a theoretical assumption. I thought that after three years of teaching one would be comfortable with establishing routines, constructing lesson plans, and teaching in general. Therefore, I believe that teachers with three or more years of
experience would be more likely to integrate metacognition especially within science lessons which can be overwhelming content wise for teachers. More specifically, I looked at the quality of their responses to the open-ended questions as well as the length of the responses as there were some that were clearly eager to share their experiences with integrating metacognition. The selected interviewees provided very concrete, practical, and detailed responses. I also looked for teachers with different ways of integrating metacognition. The interviews focused upon describing the integration of metacognition into participants’ classrooms and science lessons, addressing Research Question 3 more thoroughly. I prompted the participants to discuss additional resources or support that they needed in order to help them with integrating metacognition while gaining an understanding of their perceived barriers, addressing Research Question 4 in more detail than the questionnaire. Using exact language from the participants increased validity and helped ensure that the participants better understood the questions (McMillan & Schumacher, 2010).

As a result of the distance between the selected interview participants and me (the researcher), interviews were conducted by phone. I was worried about developing a rapport with my participants through this method so a few minutes at the beginning of each interview were dedicated to chatting with the participants informally about their week and such. I found that, despite the distance, a strong rapport was formed between the participants and me as the interviews all lasted an hour or more, and all of the participants were quite interested in my work. Also, participants were quite excited to share their experiences surrounding integrating metacognition into science. All interviews
were recorded using three technological audio recording devices while the participants were put onto speakerphone for the interview. All interview participants were assigned pseudonyms to maintain their confidentiality. I personally transcribed all of the interviews verbatim and then generated summaries highlighting key points from each interview so that each participant was offered the opportunity to member check. These summaries were sent to each participant to clarify my interpretation of the data. Two interviewees took the opportunity to revisit their transcripts and revise their statements.

**Summary of Data Collection**

A summary chart (Table 2) has been constructed to display the different methods of collecting data and how they relate to the research questions for this study. The overall outcomes for each phase are linked to the appropriate data source, analysis procedures, and research questions.
Table 2: Research Questions, Data Collection Tools, Analysis Procedures, and Outcomes

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Source(s)</th>
<th>Analysis Procedure</th>
<th>Overall Outcome</th>
</tr>
</thead>
</table>
| 1. How do Ontario elementary teacher conceptualize metacognition? | Questionnaire: Open-ended questions, Likert-type questions  
Semi-structured interviews: Audio recordings of participants’ responses | Statistical analysis using computer software program  
SPSS to present descriptive statistics for teacher responses  
Coding and themes using ATLAS.ti | A better understanding of what Ontario elementary in-service teachers know about metacognition |
| 2. What is the relationship between metacognitive beliefs and actions in elementary teachers? | Questionnaire: Likert-type questions | Statistical analysis using SPSS to perform reliability analysis, independent t-tests, and multiple (hierarchical) regression | A diverse collection of Ontario teachers’ beliefs about metacognitive thinking |
| 3. How do Ontario elementary teachers integrate metacognition into their elementary science lessons? | Semi-structured interviews: Audio recordings of participants’ responses | Coding and themes using ATLAS.ti | A rich and detailed description of multiple cases that demonstrate diverse integration of metacognitive practices into elementary science contexts |
4: What facilitates and hinders teachers’ integration of metacognition into elementary science lessons?

<table>
<thead>
<tr>
<th>Questionnaire:</th>
<th>Coding and themes</th>
<th>An understanding of how we can better support teachers in their efforts at integrating metacognition into elementary science lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open-ended question</td>
<td>using ATLAS.ti</td>
<td>Semi-structured interviews: Audio of participants’ responses</td>
</tr>
</tbody>
</table>

Data Analysis

Preliminary Quantitative Analyses

The quantitative data from the survey (Likert-type scale responses) were exported from FluidSurveys into Excel. All completed responses and incomplete responses from two additional respondents were included for a total of 41 responses. Item 37 ‘metacognition is only appropriate for high achieving students’ had to be reverse-coded. Ratings for 5 became 1, 4 became 2, 3 remained 3, 2 became 4, and 1 became 5 only for this item. Demographic questions were assigned codes: 1 for males and part-time; 2 for females and full-time. Following the sorting and cleaning of the data, they were analyzed using the Statistical Package for the Social Sciences (SPSS) software. A new variable ‘Experience’ was created, as participants were grouped into either veteran or early teachers, dependent upon their number of years of experience. Teachers with 0-5 years of experience were categorized as ‘early’ teachers, whereas those with 6 or more years of experience were categorized as ‘veteran’ teachers. This grouping resulted in 22 early teachers and 19 veteran teachers. The significance level for all statistical analyses was set
Based upon the 41 statistically analyzed responses, a larger portion of respondents had Bachelor of Arts degrees (69%) compared to the 31% who had Bachelor of Science degrees. Only 17% of questionnaire respondents had Master’s degrees. Respondents for the questionnaire ranged in the number of years that they had been certified through OCT (Ontario College of Teachers). The mean number of years was 7.34 indicating more experienced teachers tended to answer the questionnaire. Experience ranged from 0.5-25 years with three years of experience being the most frequent response (6 respondents).

Three reliability analyses were run with the first one focusing on obtaining the Cronbach’s alpha for all of the Likert-type questions grouped together (beliefs and actions). Then the items were divided into two groups: beliefs or actions. The first group contained belief items that focused on teachers’ beliefs about metacognition. The second group focused on actions that teachers executed to promote or integrate metacognition. An item representative of beliefs would be ‘Metacognitive thinking is appropriate for intermediate and senior students (Grades 7-12).’ An example of an item representative of teachers’ actions would be ‘I consistently model what I am thinking for my students when I am working through a problem, investigation, or task in science.’ The second reliability analysis was run for the belief items and the third reliability analysis for the action items.

**Correlational Analysis**

A correlational analysis was used to determine the Pearson product-moment correlation coefficients between variables. Pearson correlation coefficient is a measure of
the strength and direction of the relationship. Correlations were calculated among gender of participants, years of experience of participants, teachers’ metacognitive beliefs, and teachers’ metacognitive actions. A two-tailed significance test was used. Total scores for the 11 “belief” items and 15 “action” items were calculated separately for each participant. A total score was calculated by adding up all the belief items for each participant. The same method was used to calculate a total score for the action items for each participant. Mean scores for items within a specific scale for a participant were added in for any items that had missing data. The total scores were used for all quantitative analyses.

**Inferential Analyses**

Four independent t-tests were run to investigate whether or not teachers’ responses to the Likert-type items differed significantly according to their years of experience. These t-tests were run, rather than ANOVAs, to avoid Type II error within this exploratory study. The first t-test examined differences in teachers’ beliefs according to gender. The second t-test examined differences between males and females for teachers’ actions. The third t-test examined differences between early and veteran teachers according to their reported beliefs. The fourth t-test examined differences between early and veteran teachers according to their reported actions. The confidence interval was calculated at 95%.

Next a hierarchical multiple regression analysis was performed to explore the extent to which years of experience, gender, and teachers’ beliefs collectively predicted teacher actions. In the analyses, the total actions score was entered as the dependent
variable, with experience and gender entered as the independent variables in Block 1, with total beliefs added in Block 2.

**Qualitative Data Analysis**

Following transcription, all documents were imported into Atlas.ti for analysis. The interviews were each coded individually; then coding was completed across the interviews. During individual coding, I mapped each coded segment onto my research questions to increase the likelihood that the data I was coding were relevant to the current research study. The codes were the smallest individual units of analysis. Preliminary coding of the first two interviews was completed and then discussed with my supervisor so that I could clarify my thinking and justification for the assigned codes. Following the preliminary coding, I went back and refined my coding for the first two interviews. I continued to use a more refined coding process for the remaining interviews. Codes that were similar were grouped together to generate larger themes across the qualitative data (open-ended questionnaire responses and interview data). A breakdown of codes from the interviews can be seen in Table 3. I found that this process helped the codes to emerge from the data, while remaining focused around the data pertinent to my research questions. I consistently referred back to my own conceptualization of metacognition and earlier chapters while coding so that I was immersed in the data but also in a deeper understanding of metacognition. Summaries highlighting key points and interpretations from the interviews were generated. All interview participants had the opportunity to check and comment on these summaries as they each received an individualized summary. Only Amanda and David responded and approved the summaries.
Table 3: *Summary of codes used for analyzing interview data.*

<table>
<thead>
<tr>
<th>Interview Participant</th>
<th>Total Codes</th>
<th>Total Segments Coded</th>
<th>Sample of Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Amanda</td>
<td>50</td>
<td>131</td>
<td>-Teacher modelling&lt;br&gt;-Positive mindset&lt;br&gt;-Making thinking visible to teacher and peers&lt;br&gt;-Student self-awareness&lt;br&gt;-Developing metacognitive awareness&lt;br&gt;-Thinking out loud</td>
</tr>
<tr>
<td>2-David</td>
<td>51</td>
<td>107</td>
<td>-Developing metacognitive knowledge&lt;br&gt;-Different ranges of thinking&lt;br&gt;-Getting to know students as learners&lt;br&gt;-Strategies across subjects&lt;br&gt;-Questioning as a strategy to encourage metacognitive thinking</td>
</tr>
<tr>
<td>3-Jacob</td>
<td>30</td>
<td>80</td>
<td>-Asking students about their thinking&lt;br&gt;-Barriers to implementing metacognitive practices&lt;br&gt;-Explicit instruction on learning strategies&lt;br&gt;-Growth mindset&lt;br&gt;-Students monitoring their learning</td>
</tr>
<tr>
<td>4-Ben</td>
<td>25</td>
<td>68</td>
<td>-Conceptualizing metacognition&lt;br&gt;-Creating a classroom learning culture&lt;br&gt;-Helping students to articulate their thinking and learning strategies&lt;br&gt;-Learning through dialogue&lt;br&gt;-Prompts for articulating metacognitive</td>
</tr>
<tr>
<td>5-Anna</td>
<td>45</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>--------</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>thinking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Encouraging students to justify their thinking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Explicit metacognitive prompts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Language skills as a barrier for articulating and making student thinking visible</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Metacognitive thinking without prompting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Sharing strategies</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chapter 4:

Results

This study examined Ontario elementary teachers’ perspectives on metacognition and their beliefs about elementary students’ abilities to be metacognitive in science. Four research questions guided this study:

1. How do Ontario elementary teachers conceptualize metacognition?
   a) What assumptions do participants have about metacognition?
   b) What misconceptions do participants hold about metacognition?

2. What is the relationship between metacognitive beliefs and actions in elementary teachers?

3. How do Ontario teachers integrate metacognition into their elementary science lessons?
   a) Describe Ontario teachers’ experiences with integrating metacognition.

4. What facilitates and hinders teachers’ integration of metacognition into elementary science lessons?
   a) What resources help teachers integrate metacognition into elementary science lessons?
   b) What are some perceived barriers or difficulties that elementary teachers report as impacting their integration of metacognition into science?

The results of this study are organized around each of the four research questions with the relevant themes discussed. Both quantitative and qualitative data are reported.
Although some questions may focus more on one type of data, each of the four research questions was clearly represented through both types of data. I did my best to not blur the boundaries between research questions and to document my reasoning throughout my research journal. For clarification, respondents are those who responded to the questionnaire (Phase 1) and interviewees were those who participated in semi-structured interviews (Phase 2). Prior to examining the research questions, I present the descriptive statistics for the questionnaire.

**Descriptive Statistics**

Descriptive statistics were calculated to describe the Likert-type items. A summary of these results is found in Table 4.

**Table 4: Summary of Descriptive Statistics (N=41)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. It is important to teach students how to think about their thinking and learning.</td>
<td>4.68</td>
<td>.521</td>
</tr>
<tr>
<td>13. I believe that young children (Grades K-3) can think about their thinking and learning.</td>
<td>4.46</td>
<td>.596</td>
</tr>
<tr>
<td>14. I provide students with time to reflect on their learning after completing a science task.</td>
<td>3.83</td>
<td>.738</td>
</tr>
<tr>
<td>15. I encourage students to 'think aloud' (say what they are thinking out loud) when they are completing tasks in my science lessons.</td>
<td>3.93</td>
<td>.848</td>
</tr>
<tr>
<td>16. I consistently model what I am thinking for my students when I am working through a problem, investigation, or task in science.</td>
<td>3.98</td>
<td>.689</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>17. I explore the best processes of learning science with my students.</td>
<td>3.73</td>
<td>.775</td>
</tr>
<tr>
<td>18. I develop a language with my students to describe our thinking and learning in science.</td>
<td>3.66</td>
<td>.855</td>
</tr>
<tr>
<td>19. I give my students time to demonstrate how they get to their science ideas (their thought processes).</td>
<td>3.85</td>
<td>.691</td>
</tr>
<tr>
<td>20. I encourage students to ask questions about their learning processes in science (before, during, and after a task).</td>
<td>4.10</td>
<td>.735</td>
</tr>
<tr>
<td>21. I help students understand how their feelings impact their science learning (e.g. addressing feelings of difficulty or certainty).</td>
<td>3.51</td>
<td>.925</td>
</tr>
<tr>
<td>22. I help my students understand how to use their feelings to positively impact their learning in science.</td>
<td>3.49</td>
<td>.952</td>
</tr>
<tr>
<td>23. All students can think about their learning.</td>
<td>4.61</td>
<td>.586</td>
</tr>
<tr>
<td>24. I help guide my students through planning their learning in science.</td>
<td>4.05</td>
<td>.740</td>
</tr>
<tr>
<td>25. I help guide my students through monitoring their learning in science.</td>
<td>3.98</td>
<td>.689</td>
</tr>
<tr>
<td>26. I help guide my students through evaluating their learning in science.</td>
<td>3.95</td>
<td>.669</td>
</tr>
<tr>
<td>27. I provide students with examples of different ways to plan their learning in science.</td>
<td>3.63</td>
<td>.859</td>
</tr>
<tr>
<td>28. Metacognitive thinking is appropriate for intermediate and senior students (Grades 7-12).</td>
<td>4.76</td>
<td>.538</td>
</tr>
<tr>
<td>29. Metacognitive thinking is appropriate for elementary students (Grades K-6).</td>
<td>4.68</td>
<td>.521</td>
</tr>
<tr>
<td>30. Metacognitive thinking develops with practice.</td>
<td>4.71</td>
<td>.512</td>
</tr>
<tr>
<td></td>
<td>Statement</td>
<td>Mean</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>31.</td>
<td>It is necessary to teach different metacognitive strategies for different subjects.</td>
<td>3.78</td>
</tr>
<tr>
<td>32.</td>
<td>I understand and am consciously aware of the different metacognitive strategies that I use when I teach.</td>
<td>3.56</td>
</tr>
<tr>
<td>33.</td>
<td>After teaching and using metacognitive strategies I give students time to identify what does and does not work well for them.</td>
<td>3.71</td>
</tr>
<tr>
<td>34.</td>
<td>It is important to provide opportunities for students to share their thinking (before, during, or after learning) with their peers and teacher.</td>
<td>4.41</td>
</tr>
<tr>
<td>35.</td>
<td>Students are responsible for their learning in elementary years.</td>
<td>3.85</td>
</tr>
<tr>
<td>36.</td>
<td>Students can regulate (monitor, plan, and evaluate) their learning in elementary years.</td>
<td>4.10</td>
</tr>
<tr>
<td>37.</td>
<td>Metacognition is only appropriate for high achieving students (reversed).</td>
<td>4.24</td>
</tr>
</tbody>
</table>

The overall reliability of the Likert-type questions was .884 for the 26 items.

Separating the 26 items into two separate scales based on the conceptual basis for the questions, the reliability for the beliefs scale was .720 (11 items) and for the actions scale .908 (15 items). Cronbach’s indicated an acceptable reliability for the beliefs scale, an excellent reliability for the actions scale, and a good reliability for the total scale overall (George & Mallery, 2003). None of the items was eliminated, as the differences to the reliability were marginal had any items been removed.
Examining Research Questions

Research Question 1: How do Ontario elementary teachers conceptualize metacognition?

An open-ended question asked respondents to describe how they explained metacognition to parents or guardians of their students. This question produced data that demonstrated how the respondents conceptualized metacognition. The three main themes from this open-ended question and from interview responses addressing the first question were:

1. Reflecting on your thought process is a key component of metacognition;
2. Metacognition is the ability to understand, regulate, and be aware of your thinking and learning. This ability includes understanding your strengths, needs, and strategies;
3. Understandings of metacognition are sometimes inaccurate and unclear.

Participants often referred to reflection when describing metacognition (Theme 1). Participants talked about how reflection was an important part of the metacognition process. As a respondent answered, “reflecting on how you learn, what gaps are in your learning, what strategies are available may help further or deepen learning.” Another respondent described metacognition as “when students reflect back on their learning, and examine when and how they learn best, so they can use these skills to further improve their learning.” Despite reflection being referenced often when participants talked about their conceptualization of metacognition, not all participants described metacognition as
containing a reflective component, with 27% of respondents not reporting that they provided time for students to reflect on their learning in science.

Many participants were able to describe accurate components of metacognition as an ability (Theme 2), moving beyond reflection. Twelve respondents knew the literal translation of metacognition by Flavell (1979), quoting “thinking about your thinking” when asked to define the construct on the questionnaire. Other responses were more thorough and demonstrated that these participants had an accurate and detailed understanding of metacognition. However, metacognitive experiences were not mentioned by any of the participants on the questionnaire or in the interviews. Yet, 49% of respondents agreed or strongly agreed with the statement “I help my students understand how to use their feelings to positively impact their learning in science” (39% neither agreed nor disagreed). Participants tended to focus on metacognitive regulation and knowledge.

Awareness and understanding of one’s thinking were tied as the most frequently mentioned components (35%) when participants described metacognition. Strategy use was the next most frequently described component of metacognition, although only 17% of participants mentioned it. Components of self-regulated learning were included in these definitions with participants emphasizing the need for students to plan, monitor, and evaluate their learning. One respondent defined metacognition as “the ability of students to plan how they are going to approach a given task and evaluating their progress along the way.” Another respondent described the value of metacognition and demonstrated a conceptualization that aligns with the literature.
We want our students to be learners who reflect on their learning processes, have awareness of their strengths, needs, and interests and are confident developing a plan for tackling challenging work. Students who are mindful of their own personal learning experience, and can respond critically to those experiences in order to set, track, and achieve new goals, and consider new strategies in order to feel they can be successful.

Lastly, a small subset of participants expressed inaccurate and unclear understandings of metacognition when answering the questionnaire and interview questions (Theme 3). For example, three respondents and one interviewee emphasized making real-world connections as a component of metacognition but it was not clear how such connections conceptually supported metacognition as defined in the literature. Three respondents and one interviewee used metacognition and higher-order thinking interchangeably, demonstrating an unclear understanding of metacognition. Other respondents simply defined metacognition as “the knowledge students come to school with” or “it's the way we learn each individually.” These latter conceptualizations are neither consistent with key components nor clearly representative of metacognition.

**Research Question 2: What is the relationship between metacognitive beliefs and actions in elementary teachers?**

**Statistical findings.** The relationships among gender, experience, teachers’ beliefs, and actions were investigated using Pearson product-moment correlation coefficients. Gender was not significantly correlated with years of experience, teachers’ beliefs, or teachers’ actions. Years of experience was significantly positively correlated
with teachers’ actions, $r = .337, n = 41, p < .05$. Teachers’ beliefs and actions were significantly positively correlated, $r = .651, n = 41, p < .001$. Table 5 summarizes the results from the correlational analyses.

Table 5: *Pearson correlation coefficients for gender, years of experience, teachers’ beliefs, and teachers’ actions (n = 41)*

<table>
<thead>
<tr>
<th></th>
<th>Gender</th>
<th>Years of Experience</th>
<th>Total Beliefs</th>
<th>Total Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years of Experience</td>
<td>.076</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Beliefs</td>
<td>.087</td>
<td>.225</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Actions</td>
<td>.154</td>
<td>.337*</td>
<td>.651***</td>
<td>--</td>
</tr>
</tbody>
</table>

* $p < .05$, *** $p < .001$

Independent sample t-tests were conducted to investigate whether or not significant differences existed between Ontario teachers. No significant differences were found between males ($M = 44.56, SD = 15.915$) and females ($M = 46.48, SD = 7.933$) and their responses on the beliefs scale, $t(38) = -.502, p = .619$. No significant differences were found between males ($M = 54.44, SD = 14.492$) and females ($M = 55.61, SD = 8.155$) and their responses on the actions scale, $t(9.517) = -.231, p = .822$. No significant differences were found between early ($M = 44.05, SD = 12.838$) and veteran teachers ($M = 48.47, SD = 3.963$) and their responses on the beliefs scale, $t(39) = -1.535, p = .137$. A
significant difference was found between early ($M = 52.68, SD = 10.772$) and veteran teachers ($M = 59.32, SD = 7.710$) and their responses on the actions scale, $t(39) = -2.234$, $p = .028$ with veteran teachers having higher scores. Table 6 displays the group statistics.

Table 6: Summary of Group Statistics for t-Tests

<table>
<thead>
<tr>
<th>Scale</th>
<th>Comparison</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Beliefs</td>
<td>Gender: Male</td>
<td>9</td>
<td>44.56</td>
<td>15.915</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>31</td>
<td>46.48</td>
<td>7.933</td>
</tr>
<tr>
<td>Total Actions</td>
<td>Gender: Male</td>
<td>9</td>
<td>54.55</td>
<td>14.492</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>31</td>
<td>55.61</td>
<td>8.155</td>
</tr>
<tr>
<td>Total Beliefs</td>
<td>Experience: Early</td>
<td>22</td>
<td>44.05</td>
<td>12.838</td>
</tr>
<tr>
<td></td>
<td>Veteran</td>
<td>19</td>
<td>48.47</td>
<td>3.963</td>
</tr>
<tr>
<td>Total Actions</td>
<td>Experience: Early</td>
<td>22</td>
<td>52.68</td>
<td>10.772</td>
</tr>
<tr>
<td></td>
<td>Veteran</td>
<td>19</td>
<td>59.32</td>
<td>7.710*</td>
</tr>
</tbody>
</table>

** $p < .01$

Hierarchical multiple regression was used to assess the extent to which gender, experience, and teachers’ beliefs predicted teachers’ actions (Table 7). Gender and experience were entered at Step 1 and explained 13% of the variance; however, the contribution to teachers’ actions was not significant ($R^2 = .130, p = .071$). After entry of teachers’ beliefs at Step 2, the total variance explained by the model as a whole was 46.9%, $F(3, 37) = 10.907, p < .001$. The beliefs’ variable explained an additional 33.9% of variance, $R^2 = .339, F(2, 37) = 23.665, p < .001$. In the final model, only the total beliefs variable was statistically significant with a higher beta value ($\beta = .599, p < .001$). Gender ($\beta = .087, p > .001$) and years of experience ($\beta = .195, p > .001$) were not
significant. Although the first block of gender and experience was not a significant predictor of teachers' metacognitive actions, experience was a significant predictor by itself. Experience was not a significant predictor once teachers' beliefs were added.

Table 7: Summary of Multiple Regression

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th></th>
<th>Model 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>T</td>
<td>β</td>
<td>t</td>
</tr>
<tr>
<td>Gender</td>
<td>.129</td>
<td>.847</td>
<td>.087</td>
<td>.721</td>
</tr>
<tr>
<td>Experience</td>
<td>.327*</td>
<td>2.155</td>
<td>.195</td>
<td>1.585</td>
</tr>
<tr>
<td>Total Beliefs</td>
<td></td>
<td></td>
<td>.599***</td>
<td>4.865</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>.130</td>
<td></td>
<td>.469***</td>
<td></td>
</tr>
<tr>
<td>( R^2 ) change</td>
<td>-</td>
<td></td>
<td>.339***</td>
<td></td>
</tr>
</tbody>
</table>

* \( p < .05 \), *** \( p < .001 \)
**Thematic analysis.** Four main themes emerged from the data to represent Ontario teachers’ beliefs about metacognitive thinking and how these beliefs informed their actions:

1. Metacognition can develop through explicit instruction, provided students are given opportunities to practice these skills;
2. Elementary students have varying metacognitive abilities so that thinking looks different among them and must be addressed accordingly;
3. Interview participants believed that metacognition was not domain-specific compared to more than half of the questionnaire respondents who believed it was necessary to teach different metacognitive strategies for different subjects;
4. Participants’ beliefs about the value of metacognition ranged from the construct being foundational for students and of great importance to being of little importance.

*Metacognition can develop through explicit instruction, provided students are given opportunities to practice these skills.* Seventy-one percent of participants strongly agreed with the Likert-type statement, “Metacognitive thinking develops with practice.” When the responses for strongly agreed and agreed were combined, 97% of participants believed that metacognition developed with practice. Similarly, David clearly stated the need for explicit instruction when integrating metacognition, “setting them up for success is modelling it.” Ben emphasized the need for Kindergarten students to be immersed in
metacognition, “It has to be all the time everywhere. They have to be immersed in it exactly. You have to be immersed and that’s what I try to get at.”

**Elementary students have varying metacognitive abilities so that thinking looks different among them and must be addressed accordingly.** Three survey respondents felt metacognition was only appropriate for high achieving students. Two respondents believed that metacognition was more appropriate for older students. For an open-ended question about the importance for students to be able to think about their learning processes, one respondent answered, “for some ages yes. For early primary K to 2 no. It may help the older students to understand how they learn.” Similarly, another respondent reported, “different strategies for each learner can be developed. Can help when they are in higher grade levels.” In contrast, 95% of respondents stated that young children (K-3) were able to think metacognitively. An interviewee stated, “I think that kids pretty young can when you’ve done all the buildup and all the skills they can do that…You know what I kind of pictured it and I can put it together. Oh, I get it” (Amanda).

Ben qualified this understanding:

> It has a lot to do with egocentrism at this age. Metacognition is hard. Thinking about your own thinking is hard when you don’t understand, you’re not developmentally ready to understand. I should say that other people have a different thought process.

Ben described different ways that he integrated metacognition into his Kindergarten class and even used the term ‘metacognition’ with his students. He felt that
young children could be metacognitive but “they’re not ready for deeper levels of metacognition.”

David described metacognition as being on a continuum:

And my hope is that on this continuum of metacognition let’s say because there is other stuff that my students do but we are talking metacognition. So on this spectrum that we have that I can move the students along to a level that’s a little bit higher than when they first came in and whatever that may be.

These ranges existed not only across grade levels but also in classrooms: “Some students would be very effectively using metacognitive strategies and even be able to name it. But then other students definitely would not know what we’re talking about or wouldn’t be using any of those strategies” (Jacob). Varying cognitive abilities might explain these intra-class discrepancies: “So the barriers that I’ve encountered, I think that everybody can do it at some level. But some students are not cognitively ready to do it in exactly the same way as others” (Anna). Despite these differences in cognitive and developmental readiness, there were some students in Anna’s Grade 5 class who engaged in metacognition without her prompting. “Some are very at ease and think about their own thinking by themselves. Like I wouldn’t even have to do the exercises, they do it themselves. …‘Oh okay I could have improved this,’ even without me prompting them.”

Interview participants believed that metacognition was not domain-specific compared to more than half of the questionnaire respondents who believed it was necessary to teach different metacognitive strategies for different subjects. In contrast to 62% of questionnaire respondents who reported it was necessary to teach different
metacognitive strategies for different subjects, all interviewees discussed how they used strategies to integrate metacognition in science that they also used across other subjects. For example, Amanda thought “my strategies still…for metacognition were very similar to how I approached my other subjects.” Interviewees’ strategies were versatile and not specific to science. An interview participant highlighted that the content would look different in science but the strategy was still similar (Amanda). Although Jacob used similar strategies with respect to metacognition across subjects, he tended to think about integrating metacognition most in science. “With math it’s easier to focus on flash cards and repetition. Since I don’t teach reading or literacy, I haven’t had to use anything there. So it’s mostly science that I think about metacognition the most in.”

As a result of using strategies across subjects, all interviewees struggled with identifying strategies that were specific to science contexts. They talked about how they would often use a strategy in literacy or math and then think about how they could use it in science. Anna felt she could benefit from learning about more strategies. “Probably somebody who’s been using metacognition in language arts if they shared more with the science teachers or had time to think ‘how would I apply this to science?’” In that context, science teachers “would see that as applicable and listen to them [other teachers]. I don’t think something new needs to be invented. A new perspective maybe.”

Participants’ beliefs about the value of metacognition ranged from the construct being foundational for students and of great importance to being of little importance. Participants who believed metacognition was foundational and important for students emphasized that it led to more effective learning while encouraging students to
have greater responsibility for their learning. For example, one questionnaire respondent wrote, “when you think about your learning processes, you become more aware of what works for you. Students can become aware of their own needs, advocate for themselves, and become generally more responsible for their own learning.” Four respondents explicitly emphasized how metacognition encouraged students to understand their strengths and weaknesses, which helped them to become stronger learners. One respondent defined metacognition as “Thinking about yourself as a learner- being aware of strategies and tools that help you be successful, and of your strengths and needs.” Another respondent suggested that developing students’ metacognition led to an increased understanding of the content and allowed students to expand their thinking. “If they can think and understand how they think, they are more likely to understand what they are learning and in turn be able to expand their thinking and learning.” A different respondent elaborated further:

By being able to think about their learning processes, students can take steps to maximize their efforts. They won't waste time trying to learn new concepts ways that are not efficient or effective for them. By knowing their learning processes, students can then share this information with their teachers who can then make sure that they model their lessons to include these processes.

Jacob, a Grade 1 teacher, linked metacognition to self-regulated learning by emphasizing the importance of both of these constructs. Metacognition for him was “one of the more valuable… tools for children, students, and teachers for learning…self-regulation and metacognition I think are… the two biggest things that kids should do in
class... So those two I think are very, very important.” In contrast to these positive perspectives, one respondent was less convinced about the importance of metacognition and answered “limited, unimportant” when asked to comment on the value of metacognition.

Metacognition was also reported to be of value because it promoted critical thinking, increased self-confidence, and contributed to life-long learning. Seventy percent of respondents strongly agreed (95% agreed or strongly agreed) with the statement ‘it is important to teach students how to think about their thinking and learning,’ while 95% either agreed or strongly agreed (split relatively equally between the two groups) with the Likert-type statement ‘it is important to provide opportunities for students to share their thinking (before, during, or after learning) with their peers and teacher.’

**Research Question 3: How do Ontario teachers integrate metacognition into their elementary science lessons?**

Five main themes emerged from interview and questionnaire data that focused on how these Ontario teachers were currently integrating metacognition into elementary science.

1. Participants integrated explicit instruction on metacognitive strategies while modelling metacognitive skills and thinking;
2. Participants promoted strategy sharing among peers and learning from each other;
3. Participants encouraged students to articulate their thinking through whole class, group, peer, and teacher-student discussions;
4. Participants encouraged students to plan, monitor, evaluate, and reflect on their learning;

5. Participants encouraged students to have positive/growth mindsets.

*Participants integrated explicit instruction on metacognitive strategies while modelling metacognitive skills and thinking.* A respondent emphasized the process of modelling metacognition in his or her science lessons:

KWL charts (to encourage students to access their prior knowledge), teaching and modelling the scientific method to cement a format/organization for students to reach back to when planning or approaching science work, asking students to reflect on the strengths and weaknesses of their science experiments and engage in inquiry projects which challenge them to be metacognitive scientists who engage in ongoing reflection and reworking of their design plans, research and experiments...I really stress that this is an admirable feature in a scientist, and help students see that this type of ongoing metacognitive process is highly valued!

Participants talked about how they taught specific strategies while also generating a list of these strategies with students, which were posted in the classroom as visual prompts. For example, Amanda described how she had to stop students and point out strategies that were being used when they were busy interacting with each other. “I’ll let them keep going on this alright and then I’ll stop them and say, wow I just noticed another strategy over here right. So in that kids are able to once you do that enough, kids will listen and they will learn from each other’s strategies.”
Figure 2 demonstrates the most commonly used strategies by respondents when integrating metacognition into science lessons. Teachers were using modelling, ‘think alouds,’ and opportunities to reflect as main strategies for supporting metacognitive learning in science. Eighty percent of respondents agreed or strongly agreed with the statement: “I consistently model what I am thinking for my students when I am working through a problem, investigation, or task in science”; 73% indicated that they provided time for students to reflect, while 71% indicated that they encouraged students to ‘think aloud’ during science tasks. Disagreement with the statements was low (2, 2, and 1, respectively).

Figure 2: Different strategies that teachers use to support student development of metacognition

The interviewees clearly indicated that students in their classes required a lot of explicit instruction on metacognitive thinking. They prompted their students regularly to
think about their thinking and strategies used, and to guide them through reflective thinking. Ben commented on integrating metacognition in Kindergarten, “In older grades you could just you know maybe point it out. Or maybe they would reach that understanding themselves …fairly quickly. But at this age you, they need, you need to…point it out, recognize when it happens.” He elaborated further, “Not so so much in a way of praise or anything like that. Just to notice it until it becomes a habit for them to notice it themselves.”

Interviewees discussed how opportunities to reflect were ongoing throughout their lessons but that they really encouraged students to reflect back on their performance after a task. Anna talked about how she prompted reflection, “Yes like I’ll say ‘we’re reflecting back on the process, how to improve it, what we were thinking, what are misconceptions.’” Jacob emphasized that he encouraged reflective thinking but his primary students definitely required prompting. “That’s something that I definitely try to push but it’s not something that I see a lot of unprompted. Like unprompted reflection.” According to interviewees, older students in the Junior and Intermediate grades required less prompting but metacognitive thinking was not automatized for all older students.

Modelling metacognitive thinking through ‘think alouds’ was a strategy discussed by all interviewees. Participants used this strategy as a chance to walk students through their thinking and show them how they could think about their thinking. Amanda described how she thought out loud, “I learn differently. I can totally relate to the students in my class. And so when I walk them through… you might be thinking about doing this. And I’ll just walk them through it.” She expanded further, “I’m like you know
what that was a lot of fun, that worked well, I’d do that another time…I’ll be honest
where I’m like woo that was a disaster so next time I better make sure I try
this…instead.”

Both interviewees and respondents described how they encouraged students to
develop their own questions that required metacognitive thinking. Initially, they had to
model how to generate effective questions, pose them to the class, and demonstrate the
questioning process. Encouraging students to develop and ask their own questions was
evident throughout all of the interviews, even in the younger primary grades where Ben
described how naturally his students generated questions in Kindergarten science lessons.
“The activities on metacognition I would say are around science. I find that in literacy
and numeracy, it’s more dependent on my questions.” In literacy and numeracy, Ben
could “focus on their thinking and their strategies…and to reflect on those. But the
questions are usually coming from me. Whereas, in science when we’re focusing on
metacognition, the questions are usually coming from them.”

Participants promoted strategy sharing among peers and learning from each
other. Although metacognition is an individual process, interviewees encouraged their
students to share strategies and learn from each other. Ben spoke about how he really
encouraged this process in his Kindergarten classroom, indicating that, even at a young
age, students could have valuable learning experiences through interacting with each
other. “I would say also the peer-to-peer teaching of metacognition is not just dependent
on me…. I don’t want them to depend on me. I want the class to take ownership so they
can help each other.” Interviewees indicated that they still had to make the learning
explicit for students and draw students’ attention to the various strategies that they were learning from each other. They emphasized the role that dialogue played as students learned and observed strategies. Anna stressed how students could learn from each other. “I think listening to each other, they can compare and say okay well I didn’t do that but that’s interesting. Maybe I could change it and do it like they’re doing it.” Amanda also emphasized the importance of having her students discuss their strategies throughout the year. “I have them discuss their strategies a lot and that’s just ongoing throughout the year.” Ben had found dialogue to be an important factor that related to metacognition, “The more metacognitive strategies and thinking I’ve brought into my classroom, the higher the level of dialogue and the higher the level of…interest in asking…and exploring questions. And like I said most of those questions are science-based.”

**Participants encouraged students to articulate their thinking through whole class, group, peer, and teacher-student discussions.** Teachers set up a classroom culture from the beginning of the year where students felt safe and comfortable with sharing their thinking. Both interviewees and respondents discussed how in the Primary and Junior grades students needed help with articulating their thinking. Group, peer, and teacher-student discussions were used to prompt but also encourage metacognitive thinking. For example, Amanda discussed how she used group and peer discussions to facilitate the development and articulation of self-awareness. She talked about how giving students the space to share their thinking in groups and with their peers increased their confidence. This process also helped students to better understand not only where their thinking was at but also where it needed to go.
Jacob talked about the specific prompts that he used to help students articulate their thinking in class discussions. “I think the prompt of asking them about how they know what they know. It gets them started about thinking about thinking...So to think about their thinking, I guess it’s asking questions about how they think.” The think-pair-share strategy was used by interviewees and respondents to help students articulate their thinking. This strategy has students think individually about their thinking before discussing it and sharing with a partner. Anna described another strategy used in her class to encourage metacognitive thinking, “We also have...on chart paper or on bulletin boards where...each student gets to post their own thoughts about either where they want to go or what do you think is important for this type of project.” This strategy helped her students to articulate their thinking and make it visible for others to explore.

Respondents and interviewees talked about some of the vocabulary that students were encouraged to use when describing their thinking. Only 63% of respondents reported that they agreed or strongly agreed with the statement “I develop a language with my students to describe our thinking and learning in science”; 32% neither disagreed nor agreed, while 4.9% disagreed. Therefore, some participants saw developing a language to help students articulate their thinking and learning as a necessary component when developing metacognition, whereas other participants did not.

Interviewees discussed some of the terminology that they used in their classrooms to prompt metacognitive thinking. David talked about how he used ‘making your thinking visible,’ although he found that the phrase was not always accessible to all students. For example, students in his classroom whose first language was not English
found that term confusing. So he worked to tone down the terminology and ask his students explicitly about their thinking.

Two interviewees (Ben and Jacob) indicated that they actually used the term metacognition with their students, despite working in Primary classrooms (Kindergarten and Grade 1/2). Jacob also used the word “iteration” to explain how metacognition is a meta-process as you are “thinking about your thinking.” The term reflection was discussed as an accessible and frequently used term in the classrooms of all interviewees. Anna talked about how she would ask her students “what are you thinking,” as a prompt to get them talking about their metacognitive thinking. She described how her school board had an initiative focusing upon how to make students’ thinking more visible. The terminology surrounding metacognition was more often used at the teacher level, but she hoped to integrate it further into her classroom.

Interviewees discussed differences that they had noticed in their classrooms when their students were engaging in metacognition. Students were seeking clarification from peers and their teacher when they were being metacognitive. Increased student engagement was a notable difference that interviewees and respondents found when their students worked on increasing their metacognitive thinking. As David stated, “They’re more engaged because I feel like what we’re doing is we’re going deep as opposed to wide thinking.” Interviewees discussed how they were able to see explicit results in some of their students, but it still was a challenge to see how metacognition was developing in others. As Jacob stated, “I see it working definitely…with explicit results with some of them. But the majority of them…it’s hard to tell what exactly they know. That’s…the
ultimate challenge of the teacher is being able to observe what strategies are working.” Ben consistently mentioned how he had noticed an increase and improvement in the quality of dialogue in which his Kindergarten students engaged as their metacognition developed further. These differences were not always positive, as Anna discussed how some of her students struggled with reflecting on their thinking, and became frustrated. The frustration might have been as a result of always reflecting through writing tasks. Therefore, Anna would try to integrate some other reflective tasks that were not reliant on writing.

Participants encouraged students to plan, monitor, evaluate, and reflect on their learning. Interviewees and respondents emphasized that they really encouraged students. One way students were encouraged to be metacognitive was through keeping journals in science: “students are asked to think about their work through a science journal which has areas to draw out experiments and diagrams as well as room to write about thoughts” (survey respondent). This journal task exemplifies a way in which students were encouraged to plan, monitor, evaluate, and reflect upon their learning.

Students were encouraged by various activities to engage in metacognitive thinking throughout elementary science lessons. These activities ranged in the amount of structure provided, dependent upon varying students’ abilities. Jacob talked about how he had to structure his tasks and help his students plan their learning in Grade 1. “But as far as planning to learn, I guess they don’t, I try to make things as structured as I can for them but they don’t do a lot of set-up themselves.” He clarified further, “I tell them what
we’re going to be learning I guess and I structure things as well as I can for them. So it’s mostly reminders coming from me. Less of them preparing themselves to be ready.”

Participants used the ‘thumbs up’ strategy to encourage students to monitor their thinking, where teachers asked students to put their thumb up if they were thinking what the teacher or another student was thinking. Amanda prompted students to use ‘thumbs up’ when they were debriefing their thinking as a class and regulating their learning. Her students were quite good about monitoring their learning and had the self-awareness to identify when they were unable to understand concepts in science. In fact, her students could articulate their struggles to her through discussions.

Another way that participants encouraged their students to plan, monitor, evaluate, and reflect upon their learning was through KWL charts, where students are asked to identify and record what they Know about a given topic, what they Want to learn, and what they have Learned. The first two components aid students in planning their learning and are completed before they start the new content. The last section is completed at the end of the period when students record and review what they have learned.

Anna talked about how students set up their binders for new units in science and strategies that they used to monitor their learning.

I guess one of the things we do at the beginning of a science unit they draw title pages to divide up their binder. And at the back of it I have all of the vocabulary words printed and as they go along and they’ve learned new words or new concepts they highlight it. But at the beginning I get to see like, okay so they feel
confident with those words. And periodically we’ll stop and they can highlight new words or concepts that they’ve acquired that they feel comfort, confident with. So I guess it gives them an overview where they’re progressing. Is their page fully highlighted?... Or wow, there’s still there’s a lot of things that I’m confused about.

**Participants encouraged students to have positive/growth mindsets.** Many interviewees and respondents linked the development of metacognition to positive and growth mindsets. A respondent discussed the connection between self-awareness and a growth mindset. “Students who are self aware are better able to maintain a growth mindset towards learning…they can identify what they did well and what they need to improve. This way they don't shut down and decide they…aren't good enough.” The need to develop a positive attitude towards learning and encourage a growth mindset was considered to be a critical factor that affected the development of metacognition.

The value of mistakes and learning from them was emphasized at both the Primary and Junior grades within elementary education. The interviewees discussed how this concept had to be introduced right at the beginning of the year so that students understood the importance of making mistakes and then learning from them, a key component of a growth mindset.

So besides asking them…questions and using some terminology…we also focus on the value of mistakes. So one of the main things… that I try and encourage them to do is to develop that…growth mindset where they understand that their
thinking and…their intelligence levels and how much they know is very flexible.

(Jacob)

Participants emphasized the necessity of creating a safe learning culture as it helped when integrating metacognition. Getting to know one’s students as learners and building relationships with students was a strategy to support the development of metacognitive thinking. Ben discussed the necessary culture that he facilitated in his Kindergarten classroom.

And Kindergarten has to be a culture set up right from the start. And if you don’t have that, then I think it will go nowhere. Or you might have a few kids and a few learning opportunities, you know one-offs where you could get a few metacognitive pieces with the kid. But if you have a whole culture, then it’s happening all the time. In every situation and it doesn’t depend on you. They’re able to achieve understandings of metacognition as well as help other kids. Because it’s a culture as opposed to coming from me, you know it’s sort of being top-down. So it has to be spread everywhere, all of the time.

As well as setting up a positive, safe classroom learning environment, interviewees emphasized the need to understand the learners in their classroom. David stated this idea simply, “Right, so I think that the number one thing is getting to know the learners in the classroom.” Not only did interviewees see these elements as being necessary for the learning context; they also reported that they were supportive in developing students’ metacognition.
Research Question 4: What facilitates and hinders teachers’ integration of metacognition into elementary science lessons?

What resources help teachers integrate metacognition into elementary science lessons? All respondents indicated that they integrated metacognition when they taught; however, only 67% of respondents reported that they integrated metacognition when they taught science. Many interviewees and respondents talked about supportive administration as a resource for them when integrating metacognition. Participants felt that supportive administration were necessary resources when integrating metacognition. All interviewees talked about having principals and school administrators who acted as resources.

From principals who don’t get Kindergarten anyway. When a principal tries to force down, well you better focus on getting the kids to have sight words and reading level 6. You know I had that once and that was, I knew that was time for me to change schools where the principal would either ignore me or support me in the critical thinking piece and metacognition is a big big part of that. (Ben)

Amanda said that metacognition might look different in a teacher’s class depending upon the principal. It didn’t mean that teachers wouldn’t integrate metacognition but school administrators could definitely impact teaching practices.

Participants discussed learning from and with other teachers. Amanda described how her staff meetings provided opportunities for professional development and learning from her colleagues. Amanda’s principal encouraged his staff to share ideas with each other and suggested resources for them to read or use together. “It’s amazing how many
ideas are already out there. Why reinvent the wheel right? Like I said it’s already out there so let’s just share some ideas with each other for sure.” Anna also talked about learning from and with other teachers through co-planning opportunities. In fact, her school board had an initiative at the time of the interview focusing on student learning and thinking so she had been encouraged to co-plan with other teachers to get different perspectives. Various resources and strategies could be shared throughout the co-planning process as well.

All of the interviewees and many of the respondents indicated that resources about integrating metacognition were limited and few initiatives existed surrounding the concept. Therefore, participants engaged in self-directed learning about metacognition through online and other available resources. Amanda expressed her ongoing interest in finding ideas and strategies to integrate metacognition into her classroom. “Like I said it’s always a…work in progress and I’m always…just online and looking up new ideas. I love Twitter for that. …I’m always open to new ideas and trying some new things.” Participants mentioned some specific books that they had found to be helpful when integrating metacognition such as: Making Thinking Visible; How to Promote Engagement, Understanding, and Independence For All Learners; Calm, Alert, and Learning; Drive; Finding Your Element; Minds On; 17 000 Classroom Visits Can’t Be Wrong: Strategies That Engage Students, Promote Active Learning, and Boost Achievement. The EduGains resource was mentioned as one that posted a lot about metacognition and self-regulated learning. As well, Twitter seemed to be quite a popular resource for interviewees and respondents as it allowed them to find ideas from different
perspectives. The emphasis on self-directed learning resulted from limited initiatives or suggested resources about metacognition through school boards.

**What are some perceived barriers or difficulties that elementary teachers report as impacting their integration of metacognition into science?** Participants struggled with integrating metacognition and would benefit from additional resources. Thirty-three percent of respondents indicated that they struggled with integrating metacognition. They reported a very limited background on metacognition with their knowledge and understanding limited to either their undergraduate experiences, or from when they were completing their education degrees. A respondent expressed this difficulty with integrating metacognition, lack of resources, and limited background:

I did not learn a lot of metacognition teaching practices in teachers college, so I have been doing my own research. As well, I find it hard to incorporate metacognitive practice in a class of Grade 1 and 2's. This is a skill that is difficult to teach and without the proper resources it makes it very difficult. Training and/or more resources would help me.

A respondent expressed difficulty with integrating metacognition because of not thinking metacognitively him or herself. Many participants reported that they would like more knowledge about metacognition as well as tangible resources. Some respondents and two interviewees indicated that they would like resources and guidance geared towards Primary grades as they found it especially difficult to integrate metacognition at that level. Other respondents and interviewees suggested that it would be very helpful to have workshops and resources tailored to integrating metacognition into science lessons. One
respondent desired “more planning time so I could dedicate the time needed to carefully plan lessons including strategic inclusion of metacognitive tasks, collaborative planning with co-teachers to plan tasks more effectively, guidance from an instructional coach who is well-versed in metacognition.”

Participants were asked about any perceived barriers when they integrated metacognition. A wide variety of barriers were suggested by both respondents and interviewees. Some participants suggested that the Ontario science curriculum was a barrier when implementing metacognitive tasks. Interviewees and respondents indicated that, with such an extensive and detailed curriculum, it was difficult to focus on anything but ensuring students were meeting the expectations.

Meeting these curricular expectations in combination with integrating metacognition required increased time devoted to doing so.

Like with metacognition and self-regulation you really need to be consistent with it in order for it to be effective. And to the calm and integrated part and how they learn. So that’s one of the barriers, just not enough time. I think that a general act by teachers that they need to cover all this curriculum is a barrier. Thinking that they need to get through every single specific expectation in every single subject leaves us pretty stressed and thinking that we don’t have enough time to cover it all. So we don’t really slow down and take the time that’s needed to set up a class and to get them thinking about metacognition. And getting them to reflect at the end when there’s so much content to get through, it’s hard to really engage in the process. (Jacob)
Similarly, Anna indicated that time was a perceived barrier. “Time…We feel rushed in what we have to teach. So we think that sometimes metacognition would be something super…that’s a bonus if we get the time to do it. But really it shouldn’t be.” Interviewees expressed the desire to have more time in their classroom to observe students and monitor their progress, which could be difficult with larger classes.
Chapter 5: Discussion

The purpose of this study was to better understand Ontario elementary teachers’ perspectives on metacognition and their beliefs about elementary students’ abilities to be metacognitive. Selected cases of integrating metacognition into elementary science lessons within Ontario were also explored to gain insight into ways in which metacognition has been integrated into Ontario classrooms. The following research questions guided this study:

1. How do Ontario elementary teachers conceptualize metacognition?
2. What is the relationship between metacognitive beliefs and actions in elementary teachers?
3. How do Ontario teachers integrate metacognition into their elementary science lessons?
4. What facilitates and hinders teachers’ integration of metacognition into elementary science lessons?

This chapter outlines the following seven key findings from the current study and discusses them in relation to relevant research studies:

1. Participants largely understood metacognition but had some gaps in their knowledge;
2. Participants’ actions and beliefs varied based on participants’ years of experience but not their gender;
3. The majority of participants reported that primary students (Kindergarten-Grade 3) could engage in metacognitive thinking;

4. Participants reported that students’ metacognition developed with practice but required explicit instruction;

5. The majority of respondents reported that metacognition was domain-specific in contrast to all interviewees who discussed using similar strategies across subjects;

6. Participants integrated metacognition into their classrooms, although the integration was to a lesser extent in science;

7. Participants used a variety of techniques to integrate metacognition at both the Primary and Junior grade levels.

Suggestions for how these findings can be used to inform professional development and other programming for teachers are provided. Limitations for the study are identified alongside issues with generalizing the results. Lastly, future directions for this research area are proposed.

**Key Findings**

**Key Finding #1: Participants generally understood metacognition but had some gaps in their knowledge.**

Participants were able to identify key components of metacognition such as: reflective thinking; metacognitive awareness; and understanding one’s strengths, needs, and strategies. In this respect, participants tended to focus on aspects of metacognition stemming from metacognitive regulation and metacognitive knowledge. No participant mentioned metacognitive experiences. Even within their equation of metacognition with
metacognitive regulation and metacognitive knowledge, a subset of participants displayed noticeable gaps in their understanding. Some participants generalized metacognition as higher-order thinking. Others related metacognition to best teaching practices, such as encouraging students to justify their thinking and make connections, without making clear connections to metacognition, suggesting that participants could benefit from clarification and further education surrounding metacognition.

The research focusing on examining in-service teachers’ conceptions of metacognition is limited, although one recent study examined elementary teachers’ conceptions through qualitative methods. Ben-David and Orion (2013) explored 44 elementary science teachers’ perspectives on integrating metacognition into science contexts in Israel. Participants attended a professional development (PD) program focusing on the science curriculum and engaged in metacognitive activities throughout the PD. Data were collected through teacher written reflections, recordings of teachers’ discourse, and semi-structured interviews. Participants generally had negative and skeptical views toward integrating metacognition before the professional development program. Their initial knowledge of metacognition had clear gaps and misconceptions, such as metacognitive thinking only being appropriate for high-achieving students. Following the professional development program, participants were surprised at the importance and value of metacognition. They found metacognitive experiences to be the most valuable and practical component of metacognition. Participants’ views towards integrating metacognition became more positive and complete after the training.
Generally, participants from the current study did not express such skepticism or negativity towards integrating metacognition within Ontario science contexts. The difference in the findings may be as a result of varying education initiatives or training at the pre-service education levels. In the current study, participants seemed to have the foundational bases for understanding metacognition and recognized some of the important components. However, participants in both studies clearly had some gaps and misunderstandings surrounding metacognition. The misconception that metacognition is only appropriate for high-achieving students was present in the current study, although to a much lesser extent when compared to the views that the Israeli teachers had. The biggest gap in knowledge about metacognition existed in the current study around metacognitive experiences, as the participants did not report on this component. Given the importance that Israeli teachers reported and their beliefs about metacognitive experiences being the most practical component of metacognition, further education surrounding metacognitive experiences should be prioritized. The findings from the Ben-David and Orion (2013) study demonstrate that these teachers’ views could change with professional development programming.

**Key Finding #2: Participants’ actions and beliefs varied based on participants’ years of experience but not their gender**

Participants’ beliefs and actions were significantly related to years of teaching experience. Participants with greater years of experience reported more positive beliefs and an increased tendency to implement activities related to metacognition. Many veteran
participants indicated that they engaged in self-directed learning regularly around integrating new activities into their classrooms. This tendency to seek additional resources outside of the classroom might suggest a reason as to why veteran teachers tended to report integrating metacognition more extensively than teachers new to the field who were still adjusting. In terms of having more positive beliefs about metacognition, these teachers might simply have more experience with teaching and initiatives working to promote independent learning in classrooms.

Gender was not a factor that significantly affected participants’ beliefs or actions, perhaps as a result of the small sample size for males and consequent reduced statistical power. The differential representation across genders was expected in that only about 17% of elementary teachers practicing in Ontario are male (Government of Canada, 2016). There are four female elementary teachers for every male elementary teacher (Jamieson, 2007). These results may also indicate that gender is not a factor that affects Ontario elementary teachers’ beliefs about metacognition, nor does it impact their actions. A study conducted by Mai (2015) in Malaysia found that gender did not significantly affect primary science teachers’ self-perceptions about metacognition using the Metacognitive Awareness Inventory for Teachers (MAIT) (Balcikanli, 2011).

As with previous studies (Calderhead, 1991; Pajares, 1992; Woolfolk Hoy, Davis, & Pape, 2006), teachers' beliefs and actions were interconnected. These studies have suggested that teachers’ beliefs and knowledge inform their teaching practices. However, there have been instances where teachers’ reported practices were incongruent with their observed classroom practices. For example, Spruce and Bol (2015) found that American
teachers had positive beliefs about self-regulated learning and associated metacognitive practices at the elementary and middle school levels. Yet there were incongruences between teachers’ reported practices and their actual practices within classrooms; teachers did not necessarily implement all of the practices that they reported. As a follow-up, a next step for this study would be to observe teachers to see if their reported actions are reflected in their classrooms. Similar to the findings from Spruce and Bol (2015), the participants in the current study had positive beliefs about metacognition and the related self-regulated learning components such as: planning, monitoring, and evaluating one’s learning. Since participants from the current study held positive beliefs about metacognition, they should be open to learning more about the concept and how they could integrate it further into their classrooms.

**Key Finding #3: The majority of participants reported that primary students (Kindergarten-Grade 3) could engage in metacognitive thinking**

Traditionally, researchers have examined metacognition in secondary and post-secondary students. Zohar and Barzilai (2013) identified this restriction to older students as a major limitation in the field, calling for more research focusing on the elementary population, especially primary students. The age at which children are developmentally capable of thinking metacognitively has been debated for many years (Schneider, 2008; Whitebread et al., 2010; Veenman, Bernadette, Van Hout-Wolters, & Afflerbach, 2006). There has been conflicting evidence in the field with some studies finding that students begin to demonstrate metacognitive processes in late elementary years, while other studies have provided evidence of metacognitive processes in primary grades. Young
children in the early elementary grades seem to have issues with their metacognitive and regulatory processes used for complex tasks (Winne, 1997; Zimmerman, 1990), whereas students between the ages of 8 and 10 are capable of using metacognitive strategies and have basic metacognitive knowledge (Baker, 2010; Rudd 1992). These metacognitive components continue to develop throughout secondary school (Veenman et al., 2006).

Participants’ perspectives on metacognition generally aligned with research demonstrating that young children are cognitively capable of engaging in metacognition (Bronson, 2000; Whitebread et al., 2009a). The majority of participants from the current study felt children in Kindergarten through Grade 3 could think about their thinking and learning. If teachers believe that young students in the elementary grades are capable of thinking about their thinking and learning, then teachers may be more likely to integrate metacognition into their classrooms. Some participants mentioned developmental limitations when indicating that they felt elementary students were generally capable of engaging in metacognitive thinking. They acknowledged that older students (such as those in Junior grades) are likely more capable of deeper metacognition and greater independence than Primary students.

Also, participants did report that students had a range of cognitive abilities and that metacognitive thinking would be different across students, where some students would be engaging in metacognitive thinking independently and others might require more prompting.

Empirical studies have examined the extent to which primary students demonstrate early monitoring and control skills (part of metacognitive knowledge and
metacognitive regulation). Instances of young children monitoring and controlling their learning while playing in primary classrooms have been described (Whitebread, Coltman, Jameson, & Lander, 2009a). Specifically, children as young as 3 are capable of displaying early metacognitive behaviours such as planning their learning and reflecting on their learning (Whitebread et al., 2005). Despite the presence of early monitoring and control skills in young children (ages 3-5), explicit instruction is required to develop these skills further throughout elementary grades as they are not fully developed in the absence of practice and guided instruction (Lockl & Schneider, 2006; Schneider, 2008).

While metacognitive thinking tends to become more explicit with older students, participants struggled with determining the extent to which their students were being metacognitive, especially when the students were not explicit about their thinking. This has been a longstanding issue in the literature as researchers struggle with how metacognition can be measured (Baker, 2010), especially in the primary grades, with new tools under development (Whitebread et al., 2009b). Through the use of developmentally appropriate measurement tools and activities, teachers can begin to realize primary students’ potential as metacognitive learners.

The activities and prompting used to encourage students’ metacognitive thinking must be developmentally appropriate. Wellman (1978) conducted a study examining the memory capabilities of 5- and 10-year-old students. Students were asked to rank picture cards containing elements of memorization. All children were able to complete the simple memory scenarios; however, the more complex tasks elicited developmental differences. Only a small sample of the Kindergarten students was able to complete the
more complex tasks and demonstrated clear developmental limitations. Schraw and Moshman (1995) reported early cognitive use in 4-year-olds where they were capable of using theories to regulate and think about their learning, while 6-year-olds demonstrated accurate reflective thinking, a key component of metacognition.

Georghiades (2004) discussed the research relating to age limitations for student metacognition more extensively. As summarized by Georghiades, the debate as to whether or not young students can think metacognitively must move forward. Results from the current study indicated that teachers believed young children in primary grades (Kindergarten-Grade 3) can think metacognitively. Therefore, this longstanding debate needs to move forward and consider how we can support the development of metacognition in young children through developmentally appropriate activities and how we can support teachers during their integration of metacognition across different elementary grades.

**Key Finding #4: Participants reported that students’ metacognition developed with practice but required explicit instruction**

Metacognition is not an overt process (White, 1986), and students (especially at the primary level) may be unaware that they are engaging in metacognitive thinking (Rowe, 1991). More specifically, students require guided instruction on metacognition and should be active in the learning process (Kuhn, 2000; Moseley et al., 2005). For this reason, it is crucial that teachers provide explicit instruction on metacognition so that primary in particular and elementary students in general can develop their awareness around metacognition and develop metacognitive skills including: planning, monitoring,
and evaluating their learning (Papleontiou-Louca, 2003; Wilson & Bai, 2010). Participants from the current study reiterated that explicit instruction helped students to develop their metacognition.

For example, Zohar and Peled (2008) examined how explicit instruction of metastrategic knowledge (MSK) affected low- and high-achieving elementary students. MSK constitutes knowledge about one’s cognitive procedures, including strategy use. To align MSK with the conceptualization of metacognition used in this study, MSK includes the procedural and conditional knowledge, knowing how, when, and why to use strategies. Forty-one Grade 5 students were divided into either the control or experimental group with an approximately equal number of low- and high-achieving students per group. The experimental group received explicit instruction of metastrategic knowledge (focusing on strategy use), whereas the control group received science lessons on seed germination for the same time period. Both groups completed the science lessons on seed germination; however, the experimental group had two sessions when the intervention took place, while the control group continued with designing science experiments around seed germination. Interviews were used to report students’ strategic and metastrategic levels of knowledge. Strategy use and MSK improved for both low- and high-achieving students following the intervention. These strategy levels were maintained after two weeks and three months following the intervention with explicit instruction especially important for low-achieving students.

While not in the science domain, Perry and VandeKamp (2000) examined elementary classroom contexts that promoted the development of students’ self-regulated
learning (SRL) skills in language and literacy. Classroom observations were conducted in five primary classrooms and students nominated by the observed teachers were interviewed. Three of the five teachers exemplified explicit approaches to teaching and provided structure for students while learning. Explicit instruction provided foundational support for students and helped them develop their SRL skills. Students engaged in complex reading and writing activities despite being in primary grades. Students in the observed classrooms exhibited strong metacognition and motivation, and were strategic in their learning.

In line with the extant literature, participants from the current study understood the importance of explicit instruction as a best practice. They realized that students’ metacognition and self-regulated learning skills can develop with practice in subject matter areas, such as science, but that students benefitted greatly from targeted and guided instruction on metacognition.

**Key Finding #5: The majority of respondents reported that metacognition was domain-specific in contrast to all interviewees who discussed using similar strategies across subjects**

The lack of consensus articulated in the field of metacognition surrounding whether or not it is domain-specific (Veenman et al., 2006) was reflected in the findings of the current study. The majority of survey respondents reported that it was necessary to teach different metacognitive strategies for each subject domain. In contrast, all of the interviewees felt that metacognitive strategies generally could be used across subject domains and discussed using them in a variety of contexts. Although most of the
respondents recognized the importance of teaching students how to think about their thinking and learning, their belief in the domain specificity of the concept might affect their integration of metacognition. If the majority of participants believed that metacognition looked different across subjects and they were required to teach different strategies in science when compared to literacy, it might decrease the likelihood that they would integrate metacognition into their teaching practices in that doing so would require more time.

Schraw (1998) emphasized that metacognitive knowledge and metacognitive regulation are domain-general. More specifically, he suggested that cognitive skills are domain-specific, whereas these metacognitive components can be used across subject domains. For example, metacognitive strategies (e.g., monitoring comprehension and setting goals) used in literacy could be transferred and used in mathematics and science. Gourgey (1998) provided evidence that university students were able to use metacognitive strategies (identifying goals, monitoring, questioning) in reading and in mathematics successfully. Students reported that monitoring their thinking and engaging in self-questioning while reading were quite difficult tasks for them. Following more practice and guided instruction on these strategies, students demonstrated increased comprehension and more effective strategy use. In terms of the mathematical problem-solving, students found the self-monitoring to be quite difficult. Following continued practice, encouragement, and guided instruction, students were able to successfully monitor their thinking and asked themselves appropriate questions while completing
mathematical problems. This study demonstrates that students were able to use the same metacognitive strategies in both literacy and mathematical domains.

Literacy and math contexts were often mentioned by interviewees from the current study when they discussed using general metacognitive strategies across subject domains. In fact, the interviewees were quite surprised when they were asked about the domain specificity of metacognition. They genuinely did not seem to have considered that metacognitive strategies were not to be used across subjects. Similar to the instructional account that Gourgey (1998) provided, interviewees from the current study discussed teaching general strategies (e.g., monitoring, goal-setting, self-questioning) in a way that could be applied to contexts outside of one specific subject.

The difference in beliefs about domain specificity found between respondents and interviewees demonstrates that there is still a lack of consensus around whether or not metacognitive skills and strategies can be generalized. The interviewees were quite adamant about the generalizability and versatility of metacognitive strategies. Four of the five interviewees were veteran teachers, which might influence how they viewed and used metacognitive strategies after many years of teaching. Clearly, more empirical evidence is needed to provide clarity around this issue.

**Key Finding #6: Participants integrated metacognition into their classrooms, although to a lesser extent in science**

The vast majority of participants indicated that they integrated metacognition into their elementary classrooms; however, fewer participants integrated metacognition into their science lessons. A lack of comfort with teaching science content or thinking skills
could be a result of many factors but, if teachers are uncomfortable with science content, then they may not focus on enhancing students’ learning strategies during science lessons.

Zohar (2013) conducted a study exploring the challenges found by a range of science educators in Israel when teaching higher-order thinking skills (such as metacognition). The participants reported many challenges with teaching higher-order thinking skills alongside an extensive and detailed science curriculum. For example, the challenge with integrating thinking skills into a content heavy curriculum was consistently emphasized. While encouraging the development of higher-order thinking skills such as metacognition had been a priority within the Israeli educational system for many years, yet it seemed that teachers didn’t know how to organize and implement such a curriculum. Participants also expressed issues with devising developmentally appropriate science thinking tasks. Lastly, educators indicated that they needed to be very proficient and knowledgeable about teaching higher-order thinking. Specifically, they felt that they did not have this complex knowledge relating to cognitive and metacognitive processes.

Many participants in the current study reported they had limited background in metacognition and indicated that they would like resources geared towards integrating metacognition into science lessons at the primary level, as these resources were extremely sparse. These findings coincide with the findings by Ben-David and Orion (2013) where teachers indicated that a lack of resources and support around integrating metacognition into elementary science classrooms acted as a significant barrier. As well,
elementary teachers in Israel indicated that they were interested and open to learning more about how to effectively integrate metacognition into their science lessons (Ben-David & Orion, 2013). Ontario elementary teachers in the current study were also open to learning more about effective integration of metacognition into their science lessons, especially given their understanding of the importance of metacognition.

The need for supportive administration was emphasized by participants in the current study and those from Zohar’s (2013) study. Participants in this study also noted that the Ontario science curriculum is very detailed and contains extensive expectations; therefore, they had difficulty focusing on anything other than working to have their students meet the expectations, similar to the participants from Zohar’s (2013) study. Many participants additionally reported that they would like more time to plan for the integration of metacognition into science lessons. As well, they felt that it would be beneficial to have more time for classroom observations of their students to monitor their progress. Overall, it seems that these barriers could be addressed through providing teachers with more resources on integrating metacognition and providing them with some additional opportunities to plan and learn about what metacognition might look like in their classrooms.

Key Finding #7: Participants used a variety of techniques to integrate metacognition at both the Primary and Junior grade levels

Participants integrated metacognition into their science lessons to differing extents, although they used similar techniques across grade levels. Explicit instruction was one of the most commonly discussed approaches to integrating metacognition where
participants consistently modelled their thinking in science to help walk students through metacognitive thinking. In contrast, a previous study demonstrated that few teachers provided direct instruction on how students could learn more effectively through the use of learning strategies (Hamman, Berthelot, Saia, & Crowley, 2000). The ‘think aloud’ protocol and opportunities for reflection were also used to develop students’ metacognition. Prompting students to generate, ask, and answer their own questions was a third metacognitive strategy. Teachers asked students about what worked well and did not work well while learning, rather than simply content-based questions. All of these strategies have been suggested as effective ways to integrate metacognition (Blakey & Spence, 1990; Papeontiou-Louca, 2003).

Another approach participants found helpful was encouraging students to learn from each other and to share their metacognitive thinking, for example, by discussing how they planned their learning before starting with their peers, or discussing the strategies they used that worked well for them. Despite metacognition being an individual process, participants consistently reported the need for students to share their metacognitive strategies. Further, participants fostered a learning community where students could participate in dialogues about their metacognitive thinking. Another study similarly demonstrated the value of collaborative and peer-assisted learning. Young children (3-5 year olds) demonstrated more metacognition (monitoring and control of their learning) and regulation when they collaborated with peers, compared to students who worked individually (Whitebread, Bingham, Grau, Pasternak, & Sangster, 2007).
These connections between social interactions and students’ metacognitive thinking have been well supported (Fox & Riconscente, 2008; Vygotsky, 1978).

Even though students can learn strategies from each other, explicit instruction is still required (Pintrich, 2002). Participants mentioned how they had to provide direct instruction on the strategies that students learned from their peers in that students at the elementary level need help articulating their thinking. In addition to providing explicit instruction surrounding metacognition, participants acted as facilitators of student learning in their classrooms. They encouraged students to direct and take responsibility for their own learning, promoted independent learning, and prompted students to be active in the learning process.

Participants used different activities to encourage students to plan, monitor, evaluate, and reflect on their learning. The structure of the tasks varied according to the grade level and developmental capabilities of the students. For example, science journals were used in Junior classrooms to encourage students to think metacognitively. Before, during, and after reflections were used to encourage students to engage in ongoing reflection about their thinking and learning. SMART goal setting was mentioned as an activity where students set specific, measurable, achievable, realistic, and timely goals and thereafter monitored their progress towards meeting their pre-set goals.

Participants emphasized the need to develop a positive learning community in their classrooms by promoting growth mindsets in their students. Participants felt that promoting growth mindsets helped students to think more metacognitively as students needed to feel safe sharing their thinking without fearing possible consequences. Angelo
and Cross (1993) encouraged students to identify and interact with their confusions so that students recognized the importance of addressing unclear concepts with the teacher and peers. Furthermore, Tanner (2012) emphasized the importance of developing a classroom community that promoted student metacognition in university biology courses.

**Contribution of Findings**

The findings presented here provide insight into some of the beliefs that Ontario elementary teachers have about metacognition within elementary science lessons and their integration practices. Having a better understanding of these beliefs and practices can inform the design of resources and professional development opportunities for teachers. The majority of research in the metacognition field has been within literacy and math contexts (Carrell, Gajduske, & Wise, 1998; Pressley, 2002). Therefore, this study provides a glimpse into ways in which metacognition can be integrated into elementary science education contexts. The results also present ways through which we can better support teachers as they work to integrate metacognition into their classrooms. Overall, the participants demonstrated that they generally had positive beliefs about metacognition and had some accurate conceptualizations. Further, they indicated that they want to work to better integrate metacognition into science but required more resources and support.

**Implications for Practice**

Since many participants reported that they taught different metacognitive strategies across subjects, it would be beneficial to provide Ontario elementary teachers with more resources and professional development opportunities. These resources should focus on how metacognition could be further integrated into their classrooms and into
science lessons. Also, it would be beneficial to address the misconceptions that still exist surrounding metacognition such as it is only appropriate for high-achieving students. Ontario elementary teachers could benefit from further clarification on exactly what metacognition entails, as some conceptualizations were unclear or inaccurate.

Further, teachers should be educated on the importance of metacognitive experiences and how they can help their students understand their affective feelings or judgments (such as feelings of uncertainty when completing a multiple choice question on a science test), which are present throughout learning. It has been recommended that researchers help teachers understand metacognitive experiences and provide suggestions for how teachers can help their students interpret these experiences (Georghiades, 2004). Students, especially at the elementary level, require explicit instruction and modelling of how to interpret these metacognitive feelings (Efklides, 2006; Flavell, 1979; 1987). Therefore, it is interesting that participants did not report on metacognitive experiences, which is traditionally understudied. Professional development opportunities could seek to clarify misconceptions while informing practicing teachers on the importance of integrating all components of metacognition into their classrooms.

Although there are some effective practices for integrating metacognition, these may not work across classrooms. Each classroom environment is unique and dynamic with a multitude of factors. Therefore, a prescriptive approach to integrating metacognition is not appropriate. More specifically, teachers would benefit from professional development focusing on how to facilitate metacognition in elementary
students. In a ‘teaching for metacognition’ approach, teachers prioritize metacognition and consider it alongside the curriculum and instructional goals (Fazal ur Rahman, 2011).

Teachers need to be aware when integrating metacognition and work to ensure that the activities are developmentally appropriate for the students. Professional development opportunities for teachers should include elements focusing on metacognitive activities geared towards Primary and Junior grades. Clearly, a one size fits all mentality is not appropriate when integrating metacognition.

**Future Directions**

After discussing the key findings from the current study, suggestions for future research should be highlighted. The current study only focused upon a subset of the population. Therefore, future research should aim to duplicate this study but with many more participants so that a better representation across Ontario’s elementary teachers can be achieved. It would be interesting to investigate if pre-service teacher candidates have similar beliefs to early and veteran Ontario teachers. Pre-service teachers will be the new teachers entering into classrooms; therefore, it is pertinent to know the extent to which they understand metacognition, whether or not they have ideas of how it can be integrated, and what their beliefs are about the concept. By gaining a better understanding of pre-service teachers’ beliefs about metacognition, it would help us identify any gaps that need to be addressed prior to their entering elementary classrooms. It would also be interesting to identify how elementary teachers’ beliefs about metacognition range across Canada, as some provinces or territories might have varying initiatives or resources on metacognition. Lastly, it would be beneficial to observe Ontario elementary teachers’
practices to see what the integration of metacognition into science lessons looks like across different grades.

**Limitations**

Despite working to decrease possible limitations throughout the current study, there are some limitations that must be outlined. I was cognizant of the following limitations and worked to minimize and address them whenever possible. First of all, the sample size was rather small and limits the ability to generalize these findings. The reliability analyses suggested that the scale overall consisting of Likert-type items used to measure teachers’ beliefs and reported actions was fairly reliable as a result of being above .8 (Field, 2013). However, the belief scale was not nearly as reliable as the action scale. Adding more belief items and rewording some of the items with low reliability might increase the lower reliability for the belief scale above its current .720. The grouping for early and veteran teachers was rather close with early ranging from 0-5 years and veteran starting with 6 or more years. However, as a result of the small sample size, I was unable to create a larger range between the two groupings. If this study is replicated, I would recommend an additional grouping of moderately experienced teachers ranging from 6-10 years.

This study primarily focused upon metacognitive knowledge and metacognitive regulation components with fewer questions about metacognitive experiences. Future research should continue to explore metacognitive experiences as they are traditionally not well-studied. The instrument used also had limitations as it was a self-report measure. Including open-ended questions on the questionnaire was intended to help provide a
clearer picture as to what Ontario elementary teachers knew and believed about metacognition. It is likely that no ceiling effect occurred where participants only selected one response on average without justifying their response. For example, participants were not selecting all ‘neither agree nor disagree’ across the Likert-type items. The possibility of a ceiling effect was considered as the data from the open-ended questions was triangulated with the Likert-items.
References


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Appendix A: GREB Clearance Letter

September 01, 2015

Miss Heather Braund Master’s Student Faculty of Education Queen's University Duncan McArthur Hall 511 Union Street West Kingston, ON, K7M 5R7

GREB Ref #: GEDUC-786-15; Romeo # 6016223 Title: "GEDUC-786-15 Examining Ontario Teachers' Perspectives on Metacognition and the Integration of Metacognition Into Elementary Science Lessons"

Dear Miss Braund:

The General Research Ethics Board (GREB), by means of a delegated board review, has cleared your proposal entitled "GEDUC-786-15 Examining Ontario Teachers' Perspectives on Metacognition and the Integration of Metacognition Into Elementary Science Lessons" for ethical compliance with the Tri-Council Guidelines (TCPS) and Queen's ethics policies. In accordance with the Tri-Council Guidelines (article D.1.6) and Senate Terms of Reference (article G), your project has been cleared for one year. At the end of each year, the GREB will ask if your project has been completed and if not, what changes have occurred or will occur in the next year.

You are reminded of your obligation to advise the GREB, with a copy to your unit REB, of any adverse event(s) that occur during this one year period (access this form at https://eservices.queensu.ca/romeo_researcher/ and click Events - GREB Adverse Event Report). An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example you must report changes to the level of risk, applicant characteristics, and implementation of new procedures. To make an amendment, access the application at https://eservices.queensu.ca/romeo_researcher/ and click Events - GREB Amendment to Approved Study Form. These changes will automatically be sent to the Ethics Coordinator, Gail
Irving, at the Office of Research Services or irvingg@queensu.ca for further review and clearance by the GREB or GREB Chair.

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Yours sincerely,

Joan Stevenson, Ph.D.  Chair  General Research Ethics Board

c: Dr. Azza Sharkawy, Faculty Supervisor Dr. Liying Cheng, Chair, Unit REB

Ms. Erin Wicklam, c/o Graduate Studies and Bureau of Research
Appendix B: Letters of Information/Consent

LETTER OF INFORMATION FOR ONLINE QUESTIONNAIRE

Examining Ontario Teachers’ Perspectives on Metacognition and the Integration of Metacognition Into Elementary Science Lessons

Dear Participant,

This research is being conducted by Heather Braund under the supervision of Dr. Azza Sharkawy in the Faculty of Education at Queen’s University in Kingston, Ontario. This study has been granted clearance according to the recommended principles of Canadian ethics guidelines and Queen’s University policies.

What is this study about? The purpose of this research is to examine Ontario elementary teachers’ perspectives on metacognition within an elementary science context, and their beliefs about elementary students’ abilities to be metacognitive. Teachers’ perspectives may include their beliefs, concerns, assumptions and understandings about metacognition.

What is involved to participate in this study? The study will require completion of an online questionnaire, which should take no longer than 30 minutes. At the end of completing the questionnaire you will be invited to indicate your interest and willingness to potentially participate in a 60-90 minute interview conducted in person or over the phone, depending upon availability. Participating in this study will require approximately 30 minutes if you participate solely in Phase 1 (online questionnaire,) or 1-2.5 hours if you choose to participate additionally in Phase 2 (interview). There are no known risks associated with this study.

Is participation voluntary? Yes. You should not feel obliged to answer any questions that you find objectionable or that make you feel uncomfortable. You may choose to withdraw from the study at any time with no ramifications. If you wish to withdraw, contact: Heather Braund at: heather.braund@queensu.ca. If you withdraw, you may request removal of all or part of your data from the study.

What will happen to your responses? Your responses will be kept confidential. Only Heather Braund and her committee will have access to this information. Your name will be replaced with a pseudonym. Results from this study may be published in professional journals or presented at relevant conferences, but any such presentations will maintain individual confidentiality. In accordance with the Faculty of Education’s policy, data will be retained for a minimum of five years. If data are used for secondary analysis they will contain no identifying information. You are entitled to a copy of the findings, if you are interested. If you would like a copy of the findings, please contact Heather Braund at: heather.braund@queensu.ca.
**Will you be compensated for your participation?** Yes, your email address will be entered into a draw to win one of two prizes consisting of resources for integrating metacognition or cash equivalent totaling $50 per prize.

**What if you have concerns?** Any questions about study participation may be directed to Heather Braund at heather.braund@queensu.ca or Dr. Azza Sharkawy at sharkawa@queensu.ca. Any ethical concerns about the study may be directed to the Chair of the General Research Ethics Board at chair.GREB@queensu.ca or 613-533-6081.

If you consent to participate in this study, click “Continue.” Otherwise you may exit the study.
Letter of Information and Consent For Interviews Conducted Over the Phone

My name is Heather Braund. I am doing a M.Ed at Queen’s University, in Ontario. The purpose of this research is to examine Ontario elementary teachers’ perspectives on metacognition within an elementary science context, and their beliefs about elementary students’ abilities to be metacognitive. Teachers’ perspectives may include their beliefs, concerns, assumptions and understandings about metacognition. It will take about 60-90 minutes to complete this interview. Are you interested in being interviewed on this topic?

In Canada, I am required to describe what I will ask you, tell you about your rights to refuse to participate, let you know where you can seek help and lots of other things about the research. I already have cleared this study with my university in Canada. After I describe each required step, I will ask if you understand and if it is okay to continue. All right? Here we go.

You are not required to take part in my research project or answer any questions you do not wish to. If you wish to skip a question, just tell me or, if you wish to quit altogether, let me know and I will erase everything we have discussed. I will not pressure you to continue if you wish to stop. Ok?

My questions will be about describing your current practices of integrating metacognition into your science lessons. I will also be asking you about any additional support or resources that may be helpful in helping you to integrate metacognition into your science lessons.

There are no associated risks with this study. I will assign you a pseudonym that will be used in place of your name in all discussions and publications of the collected data. I will also be asking you whether I can repeat/quote what you say. Are you willing to allow me to repeat exactly what you say?

If you are willing, I would like to audio record our conversation so that I can hear/look at it later so I do not miss any of your answers. We can turn it off if you wish or we can back up and erase answers if you prefer. I will erase your answers after I finish making my notes and only my committee will hear your answers. Are you willing to allow me to audio record our conversation? If not, I’ll just take notes instead; it’s not a problem. It is your call. Will you allow me to audio
record our conversation?

Do you have any questions before we begin? I want to give you some contact e-mails so you can contact me, my supervisor and someone at Queen’s ethics who may be able to help answer your questions or concerns.

Heather Braund: heather.braund@queensu.ca

Dr. Azza Sharkawy: sharkawa@queensu.ca

Char of Education Research Ethics Board: chair.GREB@queensu.ca

You can contact us anytime and we will try to the best of our ability to help. Do you understand?

That’s it. Are you ready for me to turn on the audio recorder to begin our interview? Turn it on. Hello, it is January __, 2016 and I am speaking with ___ name about integrating metacognition into elementary science lessons. I have described any risks, how to stop the interview, use of your real name and quotes, where to get help and several other required research steps so you know what to expect will happen during and after our conversation. Do you have any (more) questions? We are now ready to begin. Is that okay with you?

Begin Interview.
Appendix C: Survey and Interview Questionnaire

This survey consists of 37 questions that will ask you to describe your experiences with integrating metacognition and beliefs about student metacognition in elementary science contexts. Upon completion of the survey you will be redirected to enter your e-mail so that you can be entered into a randomized draw for a prize.

Demographic Information:

Please answer the following questions to provide some basic background information for the researcher.

1. How many years have you been a practicing teacher certified with OCT (Ontario College of Teachers)? (e.g. 4 years)

[Text Response]

2. Please check all that apply when describing your post-secondary education background. If 'other' please indicate the degree or diploma.
   - Bachelor of Arts
   - Bachelor of Science
   - General Degree
   - Bachelor of Education
   - Master’s Degree
   - Doctoral Degree
   - Other [Text Response]

3. Select your identification:
   - Male
   - Female
   - Other

4. Are you currently employed as a full-time or part-time equivalent Ontario elementary teacher?

[Text Response]

5. Describe how you would explain metacognition to the parents/guardians of your students.
6a. In your opinion, is it important for students to be able to think about their learning processes?
   - Yes
   - No

6b. Please explain your opinion expressed above.

[Text Response]

7a. Do you integrate metacognition when you teach?
   - Yes
   - No

7b. If yes, please describe how you integrate metacognition when you teach.

[Text Response]

8a. Do you integrate metacognition when you teach science?
   - Yes
   - No

8b. If yes, please describe how you integrate metacognition when you teach science.

[Text Response]

9a. Did you learn about metacognitive teaching practices?
   - Yes
   - No

9b. If you answered 'yes' to the above question please explain where you learned about
metacognition teaching practices.

[Text Response]

10a. Do you struggle with implementing metacognitive tasks in your classroom?
   — Yes
   — No

10b. If yes, please explain what you struggle with and what you would need to do this more effectively.

[Text Response]

11. What resources or support would help you to integrate metacognition into your science lessons?

[Text Response]

Please rate your responses for each statement on a scale from 1-5 with 1 being strongly disagree and 5 being strongly agree.

12. It is important to teach students how to think about their thinking and learning.
    — 1- Strongly disagree
    — 2- Disagree
    — 3- Neither disagree or agree
    — 4- Agree
    — 5- Strongly Agree

13. I believe that young children (grades K-3) can think about their thinking and learning.
    — 1- Strongly disagree
    — 2- Disagree
    — 3- Neither disagree or agree
    — 4- Agree
    — 5- Strongly Agree

14. I provide students with time to reflect on their learning after completing a science
15. I encourage students to 'think aloud' (say what they are thinking out loud) when they are completing tasks in my science lessons.
   - 1- Strongly disagree
   - 2- Disagree
   - 3- Neither disagree or agree
   - 4- Agree
   - 5- Strongly Agree

16. I consistently model what I am thinking for my students when I am working through a problem, investigation, or task in science.
   - 1- Strongly disagree
   - 2- Disagree
   - 3- Neither disagree or agree
   - 4- Agree
   - 5- Strongly Agree

17. I explore the best processes of learning science with my students.
   - 1- Strongly disagree
   - 2- Disagree
   - 3- Neither disagree or agree
   - 4- Agree
   - 5- Strongly Agree

18. I develop a language with my students to describe our thinking and learning in science.
   - 1- Strongly disagree
   - 2- Disagree
   - 3- Neither disagree or agree
   - 4- Agree
   - 5- Strongly Agree

19. I give my students time to demonstrate how they get to their science ideas (their
thought processes).
- 1- Strongly disagree
- 2- Disagree
- 3- Neither disagree or agree
- 4- Agree
- 5- Strongly Agree

20. I encourage students to ask questions about their learning processes in science (before, during, and after a task). *(Modified from Wilson & Bai, 2010)*
- 1- Strongly disagree
- 2- Disagree
- 3- Neither disagree or agree
- 4- Agree
- 5- Strongly Agree

21. I help students understand how their feelings impact their science learning (e.g. addressing feelings of difficulty or certainty).
- 1- Strongly disagree
- 2- Disagree
- 3- Neither disagree or agree
- 4- Agree
- 5- Strongly Agree

22. I help my students understand how to use their feelings to positively impact their learning in science.
- 1- Strongly disagree
- 2- Disagree
- 3- Neither disagree or agree
- 4- Agree
- 5- Strongly Agree

Please rate your responses for each statement on a scale from 1-5 with 1 being strongly disagree and 5 being strongly agree.

23. All students can think about their learning.
- 1- Strongly disagree
- 2- Disagree
- 3- Neither disagree or agree
- 4- Agree
- 5- Strongly Agree

24. I help guide my students through planning their learning in science.
25. I help guide my students through monitoring their learning in science.
   - 1- Strongly disagree
   - 2- Disagree
   - 3- Neither disagree or agree
   - 4- Agree
   - 5- Strongly Agree

26. I help guide my students through evaluating their learning in science.
   - 1- Strongly disagree
   - 2- Disagree
   - 3- Neither disagree or agree
   - 4- Agree
   - 5- Strongly Agree

27. I provide students with examples of different ways to plan their learning in science.
   - 1- Strongly disagree
   - 2- Disagree
   - 3- Neither disagree or agree
   - 4- Agree
   - 5- Strongly Agree

28. Metacognitive thinking is appropriate for intermediate and senior students (Grades 7-12).
   - 1- Strongly disagree
   - 2- Disagree
   - 3- Neither disagree or agree
   - 4- Agree
   - 5- Strongly Agree

29. Metacognitive thinking is appropriate for elementary students (Grades K-6).
   - 1- Strongly disagree
   - 2- Disagree
   - 3- Neither disagree or agree
   - 4- Agree
   - 5- Strongly Agree

30. Metacognitive thinking develops with practice.
31. It is necessary to teach different metacognitive strategies for different subjects. *(Modified from Wilson & Bai, 2010)*

- 1- Strongly disagree
- 2- Disagree
- 3- Neither disagree or agree
- 4- Agree
- 5- Strongly Agree

32. I understand and am consciously aware of the different metacognitive strategies that I use when I teach. *(Modified from Wilson & Bai, 2010)*

- 1- Strongly disagree
- 2- Disagree
- 3- Neither disagree or agree
- 4- Agree
- 5- Strongly Agree

33. After teaching and using metacognitive strategies I give students time to identify what does and does not work well for them. *(Modified from Wilson & Bai, 2010)*

- 1- Strongly disagree
- 2- Disagree
- 3- Neither disagree or agree
- 4- Agree
- 5- Strongly Agree

34. It is important to provide opportunities for students to share their thinking (before, during, or after learning) with their peers and teacher. *(Modified from Wilson & Bai, 2010)*

- 1- Strongly disagree
- 2- Disagree
- 3- Neither disagree or agree
- 4- Agree
- 5- Strongly Agree

35. Students are responsible for their learning in elementary years. *(Modified from}
36. Students can regulate (monitor, plan, and evaluate) their learning in elementary years.
(Modified from Lombaerts, 2009)
- 1- Strongly disagree
- 2- Disagree
- 3- Neither disagree or agree
- 4- Agree
- 5- Strongly Agree

37. Metacognition is only appropriate for high achieving students.
- 1- Strongly disagree
- 2- Disagree
- 3- Neither disagree or agree
- 4- Agree
- 5- Strongly Agree

Further Participation: Would you be interested in completing an interview describing your experiences with integrating metacognition in the 2nd phase of this study? Interviews will be conducted in person or over the phone. Please provide your e-mail below if you are interested:

[Text Response]

Interview Protocol

Part A: What does metacognition look like in your practice?

1. How do you get students to think about their thinking?
   a) How do you help students to plan their learning?
   b) How do you help students to regulate (monitor) their learning?
   c) How do you help students to reflect on their learning, during and at the end?
2. Describe any terminology that you use in the classroom relating to students’ thinking and learning.

**Alternative phrasing:** Discuss the dialogue that you would engage in with your students to help them foster thinking about their thinking and learning.

**Prompt:** Do you use particular kinds of language to focus students on their thinking and learning?

**Prompt:** Children friendly language?

### Part B: What does metacognition look like in your science practice?

3. In science class, how do you engage students in metacognitive thinking?

**Prompt:** If I came in and watched your students, what would I see?

4. Discuss what metacognitive thinking looks like in your science classroom.

**Prompt:** If I watched your teaching, what kind of metacognitive tools would I see?

5. A way that teachers support students’ metacognitive development is through the use of learning strategies.

What are some of the strategies that you use to get students thinking metacognitively in science class?

6. Are these strategies similar to and/or different from those used in other subjects (e.g., literacy)?

7. Describe ways in which you would encourage your students to reflect upon their learning in science. (modified from Spruce, 2012)

8. Describe any differences that you have noticed when your students think metacognitively.

**Prompt:** Such as achievement, motivation, frustration, and engagement.

**Prompt:** If their answer is in a different context than science ask: how about in science?

### Part C: How is metacognition different among students?

9. If I visited your classroom, would I see a range of metacognition among your students?
Prompt: Does thinking about your thinking look different among students?

10. When students are struggling with learning a particular science concept, how do you use metacognition to help them?

11. What does it look and sound like when students are learning effectively?

Part D: What resources support you in integrating metacognition in your classroom?

12. What resources have you found to be helpful in teaching students how to think metacognitively?

13. What resources and/or support do you need to help you integrate metacognition in science lessons?

Part E: Wrap Up/Conclusion

14. What is the value of metacognition?

15. Are there any barriers to implementing metacognition in your classroom? If yes, please describe them.