THE IMPACT OF PEDAGOGICAL PRACTICE ON STUDENT INTEREST IN ELEMENTARY SCIENCE CLASSROOMS

by

Jovan F. Groen

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ABSTRACT

Using a mixed-method design, the purpose of this research was to understand interest in the elementary science classroom as affected by different teaching methods. Of particular concern was the state of interest in junior level (Grades 4-6) science classrooms. Research conducted on science interest and attitudes toward science has identified significant declines in student interest and engagement across grade levels. To remedy these concerns, it has become imperative that researchers and science educators gain a greater understanding of the growing literature in the field of interest and how this research might improve student engagement, especially at the elementary level.

Questionnaires were administered to 178 students from Grades 4-6 measuring their individual interest in science, the frequency at which they were exposed to different teaching methods in science, and the level of interest they held for each instructional approach in science class. In addition, student interviews were conducted with six students from both genders representing each grade to better understand what makes for interesting and effective teaching of science in the eyes of the students. The quantitative and qualitative components yielded largely similar findings. Results indicated that passive learning tasks, such as written work and note taking, became less popular as grade level increased, that female students maintained a greater interest in passive learning tasks than males, and that passive learning tasks had the greatest impact on predicting student interest in science. Furthermore, students reported that they were best engaged by instructional strategies that were characterized by experimentation, cooperation, relevance, and novelty. These results were used to shed light on previous research in the field, and to suggest directions for future research and practice.

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Curiosity is the very basis of education

and if you tell me that curiosity killed the cat,

I say only the cat died nobly.

- Arnold Edinborough

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CHAPTER 1: INTRODUCTION

The primary goal of science, as defined by the Science Teachers' Association of Ontario (STAO), is to understand both the natural and human-designed aspects of our world. Science refers to the processes developed by humans to examine and construct knowledge about these aspects, and the organized knowledge about the aspects obtained by these processes (STAO, 2006). As processes evolve and scientific knowledge advances, they affect, and are affected by, the values and choices made by individuals, organizations, and governments, ultimately bearing a significant impact on society (STAO, 2006). Issues that comprise the fabric of today's society, such as environmental, technological, medical, and economic issues, are becoming increasingly complex and magnify the importance of a scientifically literate citizenry (Logan & Skamp, 2008). Preparing today's youth as they construct meaning, develop understanding, and expand their thinking processes with respect to today's societal issues is in a large part the realm of science education.

Osborne and Simon (1996) broadly summarize the purpose of science education by outlining five main arguments. First, the economic argument describes how science education is necessary for the production and training of the large body of scientists, engineers, doctors, and technicians that are essential to the proper functioning of a country's economic vitality. Second, the utilitarian argument suggests that an understanding of scientific knowledge and processes is very useful in the comprehension and interpretation of everyday experiences. Third, the cultural benefit argument proposes that scientific knowledge is among society’s major achievements and should therefore be celebrated and serve as a central component in our culture's education. Fourth, the skills argument outlines that science education and the processes of inquiry developed through the practice of science generate thinking and reasoning skills that "are an essential cognitive toolkit for modern life" (p. 131). Fifth, the often highlighted literacy argument suggests that science education provides a basic conceptual understanding necessary to engage in the scientific affairs emerging from a democratic society.

While this view of the purposes of science education is shared in whole, or in part, by the global research community, it is also essential to understand the perspectives of practitioners and their governing bodies on the purpose and aims of science education within their schools. In the Ontario science and technology curriculum document, the Ontario Ministry of Education (2007) outlines the skills, knowledge, and attitudes that students need to develop for future success. The three principal goals are listed as: 1. To relate science and technology to society and the environment; 2. To develop the skills, strategies, and habits of mind required for scientific inquiry and technological problem solving; 3. To understand the basic concepts of science and technology. The curriculum document further discusses the importance of an understanding of the nature of science among students. This understanding includes what scientists do as individuals, how scientific knowledge is generated and validated, and the benefits, costs, and risks involved in the use of this knowledge.

As the impact that science and technology have on society continues to grow, the importance of science education at all levels is gaining recognition. However, in contrast to the increase in societal impact, we observe a problematic trend in science education. While the importance and impact of science and science education have risen, the interest and enthusiasm in science of our youth have declined (Osborne, Simon & Collins, 2003; Resnick, 2005; Simon, 2000; Simpson & Oliver, 1990). While research on attitudes toward science has been ongoing for over four decades, evidence of significant declines has only recently come to the forefront (Osborne et al., 2003; Resnick, 2005). These declining attitudes are not exclusive to North America. Research in countries across Western Europe, the Middle East, Japan, and Australasia have also outlined the issue, highlighting a more global concern and a greater need for improved programming in science education (Christidou, 2006; House, 2006; Logan & Skamp, 2008; Murphy, Ambusaidi & Beggs, 2006; Papanastasiou, 2004). During the past decade the United Kingdom as well as the United States governments have finally recognized the increased concern over declining attitudes toward science as laid out by the academic community and have begun to invest resources into new and existing science programs. The National Commission on Mathematics and Science Teaching for the 21st Century in the United States produced a report called “Before it's too late” in 2000, noting the decline in science course enrolments at the secondary level and in attitudes and interest toward science-related subjects as early as middle school. More recent research indicates that this decline begins earlier still, at the elementary level (Jarvis & Pell, 2002; Murphy & Beggs, 2003).

What is the source of this decline in science interest? Why are so few students choosing to pursue science courses or related careers? Many factors may be at work: student attitudes are likely influenced by past experiences, personal observations, family, peers, media messages, home and school environments, and the science teacher. Summoned by a heightened level of concern, researchers examining this very question have identified through varied methodologies that factors bearing the greatest effect on attitudes toward science are pedagogical in nature (Jarvis & Pell, 2002; Kind, Jones & Barmby, 2007; Logan & Skamp, 2008; Murphy & Beggs, 2003; Myers & Fouts, 1992; Osborne et al., 2003; Piburn & Baker, 1993; Simon, 2000; Simpson & Oliver, 1990;

Singh, Granville & Dika, 2002). Consequently, in this period of review and reform within science education, there has been a renewed interest in how learning environments and varying aspects of teaching affect student learning and interest in science (Nolen, 2003). Emerging findings from recent investigations are invigorating the research community and are providing some practical recommendations to science educators. While this important research stream is advancing our understanding of the impact of interest in science education, studies have primarily focussed on the intermediate and secondary levels (Myers & Fouts, 1992; Simon, 2000; Simpson & Oliver, 1990; Singh et al., 2002). Few studies examine the decline in science interest in the elementary panel; fewer still have investigated the effects of pedagogical factors at this level.

Jarvis and Pell (2002) and Weinburgh (1995) affirm that positive childhood science experiences are predictive of academic interest and greater achievement in science throughout schooling, and that these experiences largely take place in the elementary science classroom. This research adds to the increasing evidence that interest in elementary science impacts student engagement and success in secondary school science courses and ultimately with career choice and development (Singh et al., 2002). Adding to this evidence are the mounting indications that pedagogical factors are the most influential in promoting interest and engagement in science classrooms. Together these factors point directly to the importance of effective instructional practice in science at the elementary level. With so few studies examining this demographic, let alone the effect of different pedagogical approaches in elementary science, a critical need for research in this area is evident if we wish to reverse the negative trends in science education and better prepare our youth for the complexities of their global society.

Purpose of the Study

This study sought to understand interest in the elementary science classroom as affected by different teaching methods. Of particular importance was the state of interest in junior level (Grades 4-6) science classrooms. Specifically, this study examined how student interest could be fostered through different instructional approaches and which of these was most effective. The research questions examined were as follows:

1) To what extent do grade and gender relate to situational interest, factor frequency, and individual interest?
2) To what extent do factor frequency and situational interest factors relate to each other?
3) To what extent do different situational interest factors and factor frequency relate to student interest in science, as moderated by grade level (4-6) and gender?
4) What makes for interesting and effective teaching of science in the eyes of the students?

It is the aim of this research to contribute a clearer understanding of the relationship between science interest and instructional practice. Through a better understanding of the role situational interest plays in enhancing the teaching of science, elementary educators may be better able to utilize classroom pedagogy to support the science learning of their students.

Definition of Key Terms

The key recurring concepts utilized in this study are *interest*, along with *active learning tasks*, *passive learning tasks*, *social interaction*, and *teacher modelling*, each of which represents a form of instruction or teaching strategy. This section briefly defines each concept.

In terms of education and for the purposes of this study, interest is described as a positive psychological state of attention and engagement in a cognitive activity. As qualified by the word “positive,” the disposition of interest tends to have an affective tone and is therefore generally characterized by contentment and often a sense of achievement (Chen & Darst, 2002). Interest is further defined by its interactive nature, usually between an individual and an aspect of her or his environment (Hidi & Harackiewicz, 2000).

The instructional factors examined in this study each constitute a set of similar activities that a teacher might use to teach a particular concept or topic. Active learning tasks represent those tasks that require the physical manipulation or creation of objects. This term can also be characterized by experimentation or the use of tools or measuring devices. Passive learning tasks are represented by individual activities such as reading, writing, and copying. Social interaction activities relate to cooperative forms of learning where students might work in partners, as a group, or even as a whole class. Lastly, teacher modelling is characterized by teacher-centered activities, such as a demonstration or a teacher's active description of a concept or object (Bergin, 1999).

Overview of the Thesis

This thesis is organized in five chapters: introduction, review of the literature, methods, results, and discussion. In chapter 1, the study introduces the goals and current state of science education, and identifies the connection with interest research and the need for greater integration of these fields at the elementary school level. This introductory section is followed by a description of the study purpose and principal research questions, and lastly, the definition of key terms used in the study. Chapter 2 reviews relevant literature and is divided into two major sections. The first section outlines and describes the components of interest research. The second section reviews literature in science education that relates to interest and attitudes toward science. Chapter 3 introduces the study methodology by describing the ethical clearance process, the sampling method, the study participants, the measures and instruments used in the collection of data, and the methods used to analyze the data. Chapter 4 presents the study results and is further divided into three main sections. The first outlines the preliminary quantitative results, the second presents the results of the three quantitative research questions, and the third describes the findings for the remaining qualitative research question. In chapter 5, the study results are discussed, interpreted, and related to significant research. Each research question is reviewed, followed by a section each on the limitations of the study, study recommendations, and final reflections of the research and process.

CHAPTER 2: REVIEW OF THE LITERATURE

Credited as foundational to the formation of school interest, the importance of understanding the nature of interest in elementary classrooms is often highlighted (Osborne et al., 2003). Knowledge of interest and its influences at this level may reveal the factors leading to the heavily documented decline in school science interest.

The purpose of this study was to highlight those instructional approaches that best engage students and foster interest in the elementary science classroom. This chapter is guided by this purpose and reviews relevant literature in two sections. The first section outlines student interest by introducing interest as a field of research. It further discusses the connection between research and learning, reviews historical and contemporary views of interest, and examines the ways in which interest develops. The second section describes interest in school science by outlining previous research related to student attitudes toward science, the impact of these attitudes on science achievement, and what factors influence these attitudes as moderated by grade level. From these sections, it should be evident that, as a result of the growth of the field of interest, and more specifically science interest, multiple opportunities for research are surfacing. A better understanding of the effects of interest at the elementary level could well influence instructional and curricular changes that could support both science and life-long learning.

Student Interest

Research in the area of interest, curiosity, and enjoyment has received considerable attention in the past few decades. Interest in itself is described as a state or disposition which is the outcome of an interaction between a person and a particular item, having both cognitive and affective elements as separate but interacting systems (Hidi & Renninger, 2006). It is a phenomenon that emerges from an individual's interactions with aspects of her or his environment (Krapp, Hidi & Renninger, 1992). Interest is also said to have a strong effect on cognitive functioning, and multiple studies have examined this influence through academic performance (Hidi & Harackiewicz, 2000).

Interest and Learning

As outlined by Bergin (1999) and Schraw, Flowerday, and Lehman (2001), interest is an integral part of the learning process and is positively related to both short-term and long-term learning in many ways. Children who are interested in particular activities or topics pay closer attention, persist for longer periods of time, learn more, and enjoy their involvement to a greater extent than individuals without such interests (Hidi & Harackiewicz, 2000). These students are also more likely to be intrinsically motivated as a result of doing an activity, rather than extrinsically motivated, doing it because of a particular incentive. The terms interest and intrinsic motivation are often used interchangeably but host concepts that are somewhat distinct. This distinction is related to a "person's interaction with a specific class of tasks, objects, events, or ideas. Such specificity distinguishes individual interests from other psychological concepts such as intrinsic motivation" (Krapp, Hidi, & Renninger, 1992, p. 8, as cited in Bergin, 1999). While situations that create conditions for interest also create similar conditions for intrinsic motivation, interest can also be associated with conditions for extrinsic motivation as well (Boekaerts & Boscolo, 2002).

Using similar motivational frameworks, some researchers have discussed the ability of individuals to develop interest independently and increase task performance by utilizing particular strategies through self-regulation. Sanson, Wiebe, and Morgan (1999) sought to demonstrate how students can negotiate uninteresting tasks and generate interest in those tasks that are important or required in their work. Hidi and Harackiewicz (2000) add that this ability, to intentionally regulate one's interest, would be an ideal mechanism for educators to pass on to their students. In concert with self-regulation, Schraw et al. (2001) suggest offering meaningful choices to students. They report that students who have the option of choosing tasks within a topic domain, and those who employ self-regulatory strategies in the face of uninteresting tasks, display greater interest in these tasks. The effect that choice has on interest and engagement can more easily be described by self-determination theory. This theory suggests that individuals have a psychological need for autonomy, competence, and belonging, and that choice contributes to a sense of self-determination by satisfying, in part, the need for autonomy (Deci, Vallerand, Pelletier & Ryan, 1991). While choices should be integrated into classroom instruction, researchers also recommend strong teacher guidance and feedback, especially for those students who are less knowledgeable or less self-regulated (Schraw et al., 2001).

Historical Conceptions of Interest

The concept of interest has rich historical antecedents. Often credited as a pioneer in interest research and its relation to educational psychology, John Dewey, in his book titled *Interest and Effort in Education* (1913), discussed the difference between interest-based learning and effort-based learning. Dewey offered three characteristics of interest-based learning, which were that learning was an active propulsive state, that it was based on real objects or ideas, and that these had high personal meaning and relevance to the learner (Schiefele, 1991). In contrast, effort-based learning was strictly mechanical and did not lead to deeper levels of learning. His general assumptions about interest were that it was important, that it could be promoted inside the classroom to satisfy the needs of the students, and that interest should be fostered through situational factors that encouraged challenge and autonomy (Schraw et al., 2001).

As a result of an emerging focus on behaviourism within psychology and education, research on interest began to decline in the 1920's. This decline was in large part due to the unobservable nature of interest, and that this psychological construct was not part of the emerging behaviourist philosophy (Schraw et al., 2001). It was not until mid-century that the study of interest was re-energized within a research tradition centered in personality psychology. This field focused on the study of interest as enduring personality traits (Schiefele, 1991). During the 1950's, through a series of empirical research projects gauging individuals' interests across multiple occupations and professions, Strong (1951) was able to identify that interest is established by stored knowledge about, and value for, a group of items, ideas, or even vocations. This research extended to show that interest is also an enduring characteristic that can be used to predict an individual's choices or behaviours (Boekaerts & Boscolo, 2002).

In the early 1980's, interest was re-introduced as an educationally relevant motivational concept. Emerging studies supported “three general conclusions: (a) interest is related positively to attention and learning, (b) varies from person to person, and (c) is elicited by a variety of factors such as prior knowledge, unexpected text content, text structure, and reader goals” (Schraw et al., 2001, p. 213). As such, research in interest further evolved to outline that it was possible for students: to display interest in a subject, to learn and value the process of being engaged in the area of knowledge being studied, and not to be engaged merely for the purposes of achievement (Schiefele, 1991).

With the publication of *The Role of Interest in Learning and Development* by Renninger et al. (1992) came a collection of works that grounded the descriptions and distinctions of both individual and situational interest. It was at about this time that researchers began describing how a specific type of interest (situational interest) could be generated as a result of a situation and that this type of interest had an impact on student learning through the use of a variety of teaching strategies (Boekaerts & Boscolo, 2002; Hidi, 1990).

Contemporary Views of Interest

Described as a multifaceted phenomenon, current interest theory seems to be characterized by three research lines. The first line is individual or personal interest, which best fits the typical description of interest in the sense of enjoying a particular task. The second line is situational interest, which is a constructed form of interest influenced by favourable environmental conditions. Lastly, the most recent type of interest is topic interest, a blend of both individual and situational interest geared toward specific areas of learning.

Individual interest is based on existing knowledge about and values concerning tasks, objects, or ideas and is the desire to be involved in activities related to these concepts. This type of interest is personal, broad, and often long-lasting. Hidi and Harackiewicz (2000) describe individual interest in greater detail, stating that it is "a relatively stable motivational orientation or personal disposition that develops over time in relation to a particular topic or domain and is associated with increased knowledge, value and positive feelings" (p. 152). As identified by Schiefele (1991), one element particular to individual interest is the feeling-related valence. This valence refers to an association of an object with positive related feelings, especially those of enjoyment and involvement.

Most studies examining perceptions of students with respect to a given subject or concept centre their questions on the students' individual interests. As a result, these studies assume that the interests arise from past learning and engagement with the concept, and that the student perceives these interests in terms of stored value and stored knowledge (Trend, 2005). Krapp et al. (1992) add that this stored knowledge and value are not things of which the individual is always metacognitively aware and that “interest as a psychological state influences the individual's subsequent activity” (p. 7). Students who show this type of interest often display an inner drive to learn more about the specific area. Over time it is possible to influence the development of individual interest. Bergin (1999) suggests five factors that educators can utilize when planning their instruction to more accurately align with their students' existing individual interests. The first factor he outlines is belongingness, which stems from an understanding of culturally valued items either in the culture at large or as part of a sub-culture, and personal sense of identification within a culture or specific social context. The second is emotion, which refers to connections individuals make between certain topics or activities and past experiences, whether positive or negative. The third factor is competence, highlighting that individuals who perceive themselves already as knowledgeable of content or capable at an activity will be more interested in pursuing the item being presented. The fourth focuses on relevance, indicating that an object is more interesting when it is related to a goal or pre-existing interest a person might have. The fifth factor is background knowledge and is related to an individual's existing understanding of an area and how this understanding aids in sustaining interest for the purposes of learning more.

While concurring that individual interest plays a key role in classroom instruction and learning, Hidi and Harackiewicz (2000) point out that limiting focus to students' individual interests may prove to be quite precarious. With large class sizes, it would be a considerably difficult task to create and implement individualized programs for each student, as it would be quite unlikely that students' individual interests would all be the same or even be related to the curriculum being taught. Perhaps it would be easier to use broader situational strategies to trigger a more immediate interest first.

Situational interest is transitory, contextual, and related to the learner's environment. It is the appealing effect of an activity or task. This effect is situational and therefore can quickly fade as a result of the context in which it is learned. Chen, Darst, and Pangrazi (2001) describe situational interest as "the appealing effect of an activity or learning task on an individual, rather than the individual's personal preference for the activity" (p. 384). Interest may be fostered in an area as a result of the way it has been delivered and explored over time, and individuals may choose to engage in further exploration independently.

> For example, individual interest in a particular topic may help students persevere through boring presentations or texts about that topic, and situational interest elicited by presentations or texts may maintain motivation and performance when individuals have no personal interest in particular topics. (Hidi & Harackiewicz, 2000, p. 155)

In the past few decades, research in situational interest has maintained two fairly distinct veins. A large segment of this research has focused on a specific sub-category of situational interest called text-based interest. This research examines items within a text that render it either more or less interesting, as well as how texts identified as interesting influence learning through reading comprehension and a variety of writing tasks (Hidi & Harackiewicz, 2000). Remaining research on situational interest has predominantly emphasized how the modification of specific teaching strategies can lead to increased development of situational interest. Hidi and Harackiewicz (2000) suggest that, by adopting specific instructional approaches and creating environments that stimulate situational interest, teachers can “motivate students and help them make cognitive gains in areas that initially hold little interest for them” (p. 156). Recent research has been able to outline multiple key situational factors that increase student interest in classroom tasks (Bergin, 1999; Chen et al., 2001; Hidi & Harackiewicz, 2000; Schraw et al., 2001). Outlined in Table 1 is a list of seven situational factors adapted from Bergin (1999) that positively influence situational interest and facilitate learning in the classroom. Each factor is accompanied by a brief description.

Three of the factors listed in Table 1 are examined in this study. The first is social interaction, which is examined in the context of partner projects, group work, and generally collaborating with others. The second is the hands-on factor, which is represented by doing experiments, working with tools and instruments, and physically creating or manipulating items. The third factor is modelling, which in the context of this study refers more specifically to teacher modelling and is represented by watching demonstrations or viewing a presentation about a topic.

Table 1

Situational Factors that Influence Interest

Situational Factors	Description
Social Interaction	Students often hold strong social interaction goals. If they perceive that a task will allow them to socialize, it will tend to be more interesting.
Hands-on	Interest in manipulating materials and moving around.
Novelty	When an object, situation, or idea is new or out of the ordinary, it is likely to attract attention.
Discrepancy	When faced with evidence that what they believe to be true is in fact false, students often manifest interest in resolving the discrepancy.
Modelling	Students are often influenced by models they observe, especially with respect to the treatment of the models.
Narratives	Students tend to exhibit increased attention when being told a story rather than purely analytic type discourse.
Humour	Humour is often used to maintain attention and create positive emotions, which ultimately facilitate learning.
Fantasy	Students sometimes prefer learning material when it is put into a different context.

Research in situational interest points to multiple factors that aid in increasing classroom interest, which potentially leads to more productive and enjoyable learning. However, educators should also fully establish the purposes of their instruction so that they may understand the circumstances where an exceeding focus on situational interest may be instructionally irrelevant and undermine learning (Bergin, 1999). Furthermore, not all situational factors said to promote interest are necessarily helpful to all students. According to Freeman, McPhail, and Berndt (2002), those learning activities preferred by one student may not necessarily be as effective at promoting learning for a different student. The authors further suggest that students differ in their preferred methods of learning and that factors traditionally viewed as situational triggers can instead be components of individual interest that may be enjoyable to some, but not all, students. In a qualitative study examining 47 Grade 6 students, Freeman et al. (2002) found three dimensions that, together, appeared to optimize engagement and growth of knowledge, labelling these dimensions: distractibility, diverse representations, and skill level. The researchers found that students with low levels of distraction who engage with multiple representations of content and are able to utilize a personal area of strength, sustain a greater interest in learning. The emergence of these three dimensions ultimately indicated that students were most interested in learning activities that caught their attention and engaged their dispositions and existing capabilities.

Whereas individual interest is based on an individual's enduring preferences, situational interest is generally triggered more suddenly by conditions or stimuli exposed to, or experienced by, an individual. Situational interest is also different from individual interest in that it does not necessarily involve positive feelings. In studies focussing on situational interest, positive affect is not mentioned as a necessary component. Bergin

(1999) distinguishes interest from liking by asserting that a snake can be interesting without being liked and that a type of drink can be enjoyed without being interesting. Thus a student may find a particular situational task interesting, although the affective tone of the experience may be negative (Hidi & Harackiewicz, 2000).

The latest branch of interest is called topic interest. According to Trend (2005), topic interest is “a composite: a distinct construct which may be influenced in various proportions by the more fundamental constructs of situational and individual interest” (p. 278). Other researchers (Hidi & Harackiewicz, 2000; Tobias, 1994) have utilized the term to refer to a subset of individual interest, more specifically interest in a small area of learning rather than to a wider domain of knowledge. Ainley, Hidi, and Berndorff (2002) point out the problematic nature of topic interest by suggesting that characteristics of both individual and situational interest have the potential to influence topic interest. This definition further suggests that topic interest is merely a construct defined by the interaction of both situational and individual interest.

Trend (2005) admits that the current research in interest has yet to come up with a consensual definition and understanding of topic interest. As a result of the vague and potentially problematic nature of this emerging stream in topic interest, this study focuses on factors that influence situational interest and whether or not these factors predict a more general and sustained interest in science as a whole. While measures were used to examine topic interest in the study questionnaire, the data resulting from this questionnaire component were not utilized in the analyses reported herein.

Interest Development

Most studies in interest research discuss the presence of interest, its separate characteristics, or most recently factors that might influence it. A few studies, however, have begun to outline the development of interest as a psychological state (Hidi & Renninger, 2006; Krapp, 2007). While interest development has recently been a focused component of interest research, it is not the first time that this theme has been explored. For example, in Hidi and Baird (1986), specific distinctions were outlined between those environmental factors that might lead to triggering situational interest versus those that might maintain this type of interest. Following this work, Mitchell (1993) utilized Dewey's (1913) catch and hold terminology to describe distinct situational factors that would catch a student's interest in mathematics and other factors that would effectively hold the developing interest. With the purpose of understanding student perceptions of interest in mathematics classrooms, Mitchell (1993) surveyed 350 high school students from three different schools. His findings suggested that the use of group work, computers, and logic puzzles in mathematics, especially those that were strange or unique, made students think more clearly and creatively, and aided in catching their interest. His results also emphasized, as a way of holding student interest, the importance of involvement and active participation in the learning process. For students to be genuinely interested in a subject, the topics and concepts explored in class had to be meaningful to the students in their present-day lives.

Based on research that has suggested that individual interest develops from an earlier situational interest, Hidi and Renninger (2006) defined four phases of interest development. Under the tenet of situational interest, two phases have been outlined: one which triggers interest and another that maintains it. Under individual interest, two separate phases are identified: one that characterises an emerging individual interest and a second that identifies well-developed interests. Hidi and Renninger (2006) summarize the four-phase model by outlining that the first phase of interest development triggers situational interest and allows an initial connection between person and content, which may last for a short or long period of time. The following phase is characterised by the maintaining of situational interest by external environmental factors to continue the connection between person and content and relate this content to other available information. While interest is maintained, this second phase allows for the person to begin developing value for the content with which he or she is interacting. In the third phase, called emerging individual interest, the person seeks to re-engage the content without explicitly needing external environmental supports. “He or she begins to pose curiosity questions, a process that leads to self-regulated activity, accumulation of more information, and increased valuing” (p. 119). In the final phase, individual interest becomes well-developed. Much like the second phase, the person seeks to re-engage the content and seeks greater opportunities for this re-engagement. The constructed value, questioning, self-regulatory processes, and sustained creative thinking inform this re-engagement with the content.

The conceptualization of these four phases includes both affective and cognitive components. Hidi and Renninger (2006) further specify that it is primarily the earlier phases of interest development that are characterised in terms of affect as they mainly consist of focussed attention and positive feelings. The later phases may include positive feelings but are more focused on stored value and knowledge. The four phases are distinct units that are considered to develop sequentially, provided interest is supported and maintained. Fundamental to the four-phase model is that interest, as a motivational variable, refers to the outcome of an interaction between an individual and a class of objects or ideas. Hidi and Renninger (2006) point out that:

> The potential for interest is in the person but the content and the environment define the direction of interest and contribute to its development. Thus, other individuals, the organization of the environment, and a person's own efforts, such as self-regulation, can support interest development. (p. 112)

A similar developmental model was described by Krapp (2007). Called the ontogenetic process of interest development, this model, comprised of a three-stage process, distinguishes among triggered situational interest, maintained situational interest, and finally individual interest. While quite similar in description to Hidi and Renninger's (2006) four-stage model, this process seems similar to previous catch and hold formats at the conceptual level. Krapp (2007) contends that the first phase of triggered situational interest in his model aligns closely with curiosity. He continues to outline the remaining two phases as the more central components, describing the second phase as a transitional state of attraction also known as the catch facet, and the third as a stable motivational state of enduring individual interest, the hold facet. When relating his model to an educational context, Krapp (2007) stated that,

> The question of how to hold an interest for some period of time in order to stimulate a more or less enduring state of intrinsic motivation is most important; it is not necessary to induce a longer lasting individual interest to reach this aim. (p. 14)

Consistent with research across the field of interest, Hidi and Renninger (2006), Krapp (2007), and Schraw et al. (2001) outline that the contribution of interest to the learning process is important and that the understanding of the development of interest, specifically how students sustain interest across multiple stages, carries valuable implications for classroom instruction. Ultimately, by understanding the triggering and transformation of interest, conditions that develop and sustain interest will be more easily identified. As this identification is, in part, the purpose of this study, the phases of interest development are important as they outline the continued progression of interest once it has been generated, and how this initial spark can be used in educational settings to promote individual interest in science.

Science Interest

There is little doubt that interest is an integral part of the learning process. As documented in a recent review, Osborne et al. (2003) identify that student interest in school and certain subjects decrease considerably across grade levels, beginning as early as the third grade. Furthermore, attitudes[1] toward science specifically are less positive than attitudes toward other subjects or school in general (Bennett, 2001; Logan & Skamp, 2008; Ornstein, 2006; Osborne et al., 2003; Simpson & Oliver, 1990). Science education, which seeks to evoke positive images of science and scientists as well as favourable attitudes toward the learning and understanding of science, is no longer achieving these goals and has become an area of increased concern. As a result of these concerns, researchers have continued to monitor student attitudes toward science and further examine a greater range of variables[2] used in measuring these attitudes. While this decline in attitudes is important in and of itself, it is also critical as attitudes have been found to have a significant impact on achievement (House, 2006; Singh et al., 2002).

An influential component in education, achievement is key in determining whether or not a student pursues a particular subject stream. Research in science education has sought to understand student achievement in science and what, if any,

1 Research in science education has yet to align with frameworks established in the interest research stream and therefore rarely use the term science interest; rather terms such as attitudes toward science are utilized. Similarly, terms such as teaching or classroom strategies are used in place of situational factors.
2 Variables include: anxiety toward science, value of science, self-esteem in science, and finally enjoyment of and motivation toward science (Osborne et al., 2003).

factors might predict or influence it. Singh et al. (2002) suggest that there are a number of variables related to science achievement in middle and secondary schools. Student ability, socio-economic variables, parent and peer influences, and school-related variables are all examples of these factors. Many of these factors are related to home or non-school settings and are therefore difficult to change and are often out of the control of educators. However, school-related variables, such as academic engagement, attitudes and perceptions, and knowledge of the role of science achievement in future opportunities, are amenable to change by educators. Singh et al. (2002) developed a conceptual model of attitudes and behaviours that influence science performance by correlating performance to factors such as motivation, academic engagement, and time spent on task. They concluded that science achievement was significantly influenced by motivation, attitude, and academic engagement, and that these factors could be affected by positive classroom experiences and better instructional approaches.

In parallel with Singh et al. (2002), a study performed in Japan with 7941 elementary students found that achievement in science was affected by student attitudes and consequently the classroom experiences. Investigating the relationships between instructional approaches and science achievement in Japanese elementary schools, House (2006) discovered that students who were more frequently exposed to active learning strategies, such as experimenting and working in pairs or groups, showed higher science achievement test scores. Students who often copied notes from the board also scored higher on science test scores. Conversely, students who more frequently worked with computers during science class showed a negative correlation with science achievement. Focussing more specifically on gender differences, Weinburgh (1995) reported a significant correlation between attitudes toward science and achievement in science for both genders. She emphasized that the correlation was stronger for girls than for boys, indicating that a more positive attitude is necessary for girls to achieve higher scores.

A number of different factors have been identified as influencing student attitudes toward science and their disinterest in the subject. In broad terms, research has identified demographic factors, such as age and gender (Greenfield, 1997; Jarvis & Pell, 2002; Jones, Howe & Rua, 2000; Murphy & Beggs, 2003; Osborne et al., 2003; Simon, 2000; Simpson & Oliver, 1990; Weinburgh, 1995); structural factors, such as the middle to secondary school transition as well as certain environmental and programming contexts (Logan & Skamp, 2008; Osborne et al., 2003; Singh et al., 2002); curriculum factors, such as the types of topics being taught, or the content-driven nature of the science curriculum (Murphy & Beggs, 2003; Osborne et al., 2003; Singh et al., 2002); personal factors, such as a student's background and past experiences as well as the student's perceived difficulty of science as a subject (Greenfield, 1997; Jarvis & Pell, 2002; Osborne et al., 2003; Simon, 2000; Singh et al., 2002); and lastly pedagogical factors, such as the instructional strategies used in class (Greenfield, 1997; Harlen, 1997; Logan & Skamp, 2008; Murphy & Beggs, 2003; Myers & Fouts, 1992; Jarvis & Pell, 2002; Osborne et al., 2003; Piburn & Baker, 1993; Simon, 2000; Simpson & Oliver, 1990; Singh et al., 2002). Of these factors, the most commonly mentioned variable influencing attitudes toward science and the development of interest in the subject is the pedagogical variable. Due to the paramount nature of this variable, the current study focuses on how different instructional approaches relate to greater interest in the science classroom.

Outlined in her chapter on science attitudes in the book *Good Practice in Science Teaching: What Teachers had to Say* published in 2000, Simon identifies teaching strategies as the main factor influencing student attitudes in school science. She summarizes the research field and the ample evidence pointing to the association among active learning tasks, social interaction, greater relevancy, and greater choice, with more positive attitudes toward science among secondary school students. Similarly, in an often cited study within the science education literature, Myers and Fouts (1992) sampled 699 students from 27 secondary schools across the United States examining what types of science classroom environments best related to students' attitudes toward science. Those environmental dimensions that were most influential were all related to instructional approaches. Positive attitudes toward science were best influenced by hands-on activities, student involvement and the use of cooperative activities, student-relevant topics, positive and supportive communication, and diversified teaching strategies. Additionally, in a more recent, qualitative study examining students of the same age group, Osborne and Collins (2000) interviewed 144 students, 117 parents, and 26 teachers about their perceptions of science education, and inferred that the approach currently being used in secondary schools laid too great an emphasis on passive learning activities, such as writing notes from the board, and were not stimulating or challenging enough for the students. While not including the grade levels examined in the current study, the research by Myers and Fouts (1992) and Osborne and Collins (2000) is relevant as it speaks to situational factors used by educators that aid in developing more positive attitudes toward science. The data highlighting the impact of different factors aided in the development of the present study's questionnaire. Other research showing clear declines in attitudes toward science in secondary school have suggested that, in addition to passive activities, students are generally unable to connect science to the reality that surrounds them in their everyday lives. They are unable to create meaning and relevance in the material being learned, and consequently observe science as disconnected from society at large and often contend that the subject should be studied solely for its own sake, not for its broader applicability (Bennett, 2001; Logan & Skamp, 2008; Osborne et al., 2003; Osborne & Collins, 2000; Singh et al., 2002).

While many studies thus focus solely on the secondary stream, some studies examine attitudes toward science and the pedagogical variables that influence them across a broader spectrum of grade levels. Reporting similar evidence to Myers and Fouts (1992), Piburn and Baker (1993) interviewed 149 students (83 elementary, 35 intermediate, and 31 secondary) in the North West United States to assess trends in attitude and identify the factors affecting these attitudes. The open-ended questions the authors asked related to student attitudes toward school science, instructional techniques, the nature of science, and academic and career goals in science, as well as a question asking students what they would do in science class if they were the teacher. Three general themes emerged: instructional strategies, cognitive demands, and students' ideas about how science should be taught. Students at the elementary and intermediate levels spoke largely about their enjoyment of experimentation and the actual manipulation of apparatus; they frequently expressed that activities with this type of focus provided better learning opportunities than those found in texts or worksheets. These students further mentioned disinterest in most writing activities and suggested that writing be de-emphasized in science classes. Students also indicated that they did not respond favourably to lecturing and busy work, and preferred more interactive and meaningful tasks. Finally, students commented on the need to be empowered. They felt they were rarely consulted about matters of curriculum construction and instructional approaches. These findings closely mirror a recently published longitudinal study by Logan and Skamp (2008) who monitored shifts in science attitudes and their influences on students transitioning from elementary to secondary school in New Zealand. Using qualitative techniques, the researchers found that student interest was maintained by relevant, interactive, and hands-on experiences with science content and that lecturing and written activities were less favoured. While these studies were limited to qualitative techniques and were not moderated by specific grade level, they were important in informing some of the statements used in the questionnaire. The study by Piburn and Baker (1993) is particularly significant as the authors asked what students would do in the shoes of their teachers — a question very similar in nature to one asked in the interviews within the qualitative portion of this study.

Taking a slightly different approach, Greenfield (1997) assessed students' attitudes toward, and participation in, science as moderated by gender and grade level. Students from three public schools, including elementary through secondary school grades, were first observed and then surveyed during science lessons to determine the nature of their science-related experiences and perceptions of science, as well as the relative number of teacher-student interactions and the nature of student participation in science. To facilitate analysis and as a result of the size of the overall population, the researcher collapsed the grade levels into groupings that represented the junior, intermediate, and senior levels. Greenfield (1997) found that the elementary students initiated the fewest questions in class and that the secondary students initiated the most. Conversely, elementary students received the most direct and open teacher questions, while secondary students received the least. Elementary students received more praise and feedback than either the intermediate or secondary students. Lastly, elementary students expressed the most positive attitudes toward science, followed by intermediate students. This study is unique in its examination of how students, elementary students in particular, participate and engage with material in science class. It is however limited in that the elementary panel data are collapsed into an inclusive junior level category, thereby not differentiating across grade level. Consequently, situational factors that may influence interest are not specifically discussed as moderated by grade level.

Studies specifically examining interest and the influence of pedagogical variables in elementary school science, the focus of the present research, are relatively rare. Studies examining science at this level tend to investigate issues such as the effects of teacher competence (Greenfield, 1997; Harlen, 1997; Osborne & Simon, 1996; Stark & Gray, 1999), student perceptions of science and scientists (Jones et al., 2000; Sjøberg, 2002), differing topic interests (Christidou, 2006; Jones et al., 2000; Murphy et al., 2006; Murphy & Beggs, 2003), or gender differences in science attitudes (Christidou, 2006; Jones et al., 2000; Kahle & Lakes, 1983; Murphy & Beggs, 2003; Stark & Gray, 1999; Trend, 2005; Weinburgh, 1995).

A commonly cited source of student disinterest in elementary level science is the lack of scientific knowledge and background in classroom teachers. This lack of competence in the sciences coupled with low self-confidence and fear of teaching science make these teachers unqualified and ineffective at teaching science (Murphy & Beggs, 2003). Greenfield (1997) and Harlen (1997) summarised findings from a number of related studies, concluding that children's difficulties and disinterest in science are primarily due to insufficient explanations and direction given by elementary level teachers. The lack of understanding of scientific concepts in elementary and middle school teachers often leads to the use of incorrect terminology and the over-emphasis on memorization and acquisition of knowledge rather than concept exploration and investigation (Murphy et al., 2006). Harlen (1997) highlights that often many of the explanations elementary teachers give in the science classroom are incomplete or misleading and that, in several investigations, students held these same misconceptions until the end of schooling.

As a result of her study on primary teachers' confidence and their understanding of the scientific concepts they were teaching, Harlen (1997) points out that improving teacher competence in science does not have for its purpose the production of teachers who merely lecture factual information. Rather, the purpose is to allow teachers to have enough competence in the subject to ask key questions leading students to develop and reflect on their ideas, as well as having teachers who are able to recognize and introduce relevant resources, and identify the needs and level of understanding of each student. From a different vantage point, Osborne and Simon (1996) argue that the attempts of curriculum developers and educational administrators to raise the bar in the sciences are potentially leading to inadequate pedagogy. When curriculum developers place greater expectations on the teaching of primary science, teachers often become disoriented and acquire a distaste for what they are teaching, consequently affecting student attitudes toward science. The researchers outline that perhaps a curriculum with reduced content and a greater emphasis on breadth and simple investigative work would be best suited for the current skill and resources of existing primary teachers. While this approach might alleviate some of the immediate distaste, longer-term preventative measures should be considered through pre-service teacher education or professional development, especially since the actions of the teacher play such an important role in students' understanding of and attitudes toward science.

Yet another focus of science-related studies at the elementary level is the examination of students' perceptions of science and scientists. Sjøberg (2002), in a study comparing questionnaire responses from 13-year-old students across 21 different countries, reported that the image of science and scientists is much more positive in developing countries than in developed countries. Students in developing nations expressed an eagerness to learn science as they regarded those who worked in science-related fields in very high esteem. In contrast, students in more developed nations held more negative attitudes and were more sceptical of the role of science. These students described images of mad or crazy scientists, and were less apt at visualizing scientific professions as humane and helpful. In a study involving 437 Grade 6 students, Jones et al. (2000) noted differential perceptions by gender. Boys perceived science as more destructive and dangerous as well as something that often created problems for society, whereas girls expressed a greater appreciation for the use of science in everyday life.

Of the studies examining interest in science topics among elementary students, findings are commonly differentiated by gender, and, in two particular cases, by grade level as well. Topics yielding significant preference differences for girls include: healthy living, plants, weather, and colours. Topics preferred by boys comprise: forces, electricity, light, space, and sound (Christidou, 2006; Jones et al., 2000; Murphy & Beggs, 2003; Murphy et al., 2006). As for topic preferences as moderated by grade level, Murphy and Beggs (2003) reported that, of the 16 science topics most commonly encountered in the Northern Irish elementary school curriculum, younger students aged 8-9 significantly preferred 12 topics more than students 10-11 years of age. In a separate study comparing topic preferences in the United Kingdom to those in the country of Oman, Murphy et al. (2006) found that, while student topic preferences generally decayed with age for students from the United Kingdom, equivalent numbers of topic preferences were reported between younger and older students in the country of Oman.

Identified as a key influence toward science attitudes, gender is by far the focal point of most studies involving elementary school science interest. In all related studies reviewed, boys were observed to have more positive attitudes toward science than girls, especially as grade levels increased. Greenfield (1997) found that, in the early elementary grades, girls and boys were equally interested in the science curriculum, science class, and science as a general subject, but the level of interest maintained by the girls declined at a greater rate than that of the boys beginning in the later elementary grades. When differentiated by topic, girls carried more positive attitudes toward biological sciences, while boys were more positive about the physical sciences (Christidou, 2006; Jones et al., 2000; Kahle & Lakes, 1983; Stark & Gray, 1999; Weinburgh, 1995). In contrast, Murphy and Beggs (2003) point out primary level girls were more positive about their enjoyment of science, and were shown to be more appreciative of the impact of school science on their lives than boys.

The predominant reasoning behind the gender difference in attitude toward science is said to be associated in part with cultural socialization. This theory suggests that girls have fewer opportunities to work with technological devices and be exposed to scientific phenomena (Osborne et al., 2003). A study by Kahle and Lakes (1983) reports that girls aged 9 do not experience as many science activities as boys do, even though they express interest in the topics. By age 13 and 17, the lack of science experiences remains consistent, leading to a lack of understanding, and consequently to a lack of interest and an increasingly negative attitude toward science for girls. Moreover, as a result of this lack of equal exposure, girls have restricted views of science and do not see themselves associated with this type of career. The investigators suggest that changes in classroom instruction, and teacher and parental expectations, in addition to social perceptions, are needed to promote gender equality in science classrooms. Nearly two decades later, a study by Jones et al. (2000) echoed these findings and further stated that, as a result, the profile of prospective scientists, when their student sample graduates, will be similar to the stereotypical profile observed in the 20-30 years prior.

As summarized in Greenfield (1997), another factor leading to the decline in female science interest is that materials used in science class, such as textbooks, computer software, and bulletin board material, can reinforce instructional gender bias by associating science activities and careers more with men. Also in extra-curricular settings, where boys tend to play with more explorational and electric toys, games, and computer/video software, they develop a stronger experiential background to draw upon in the classroom when solving science-related problems. Together these kinds of experiences erode female confidence and interest, which consequently affect their success with science-related pursuits in school and later in life. In contrast, Greenfield (1997) also discusses how diversified instructional strategies used in elementary schools may aid in facilitating science learning for girls and may help to enhance their science self-concept. Examples of these strategies are increased exposure to hands-on lessons and smaller group situations, which encourage more experimentation and risk-taking.

However, while Jones et al. (2000), Greenfield (1997), and Kahle and Lakes (1983) identify differing attitudes toward science and specific preferences for science topics by gender, these findings are dated and may only reflect stereotypical aversions relevant at the time of the studies, which may be more or less relevant today. These studies also neglect to examine preferred instructional approaches or teaching strategies as moderated by gender.

The only two studies located specifically examining the erosion of science interest and pedagogical influences in the elementary grades are Jarvis and Pell (2002) and Murphy and Beggs (2003). Jarvis and Pell (2002) administered over 900 surveys during each of two years, examining student views about school in general, in an effort to contextualize changes in science attitudes within the whole school experience, feelings toward science experiments, and perceptions of real-world science. Primary students had a generally positive disposition about going to school, with the youngest students being the most keen to attend. While all students were interested in hands-on tasks, working with others, and using a computer in science, only the younger primary students showed interest in reading and writing activities. Positive views about the value of science and its role in society remained stable across the elementary age range, as a reflection of students' perceptions of real-world science. Finally, consistent with the findings of Piburn and Baker (1993), the investigators documented a decline in enthusiasm for science with age. These results are counter to statements made in Bennett (2001), which outline that the deterioration of attitudes toward science only begin at the secondary level (as cited in Jarvis & Pell, 2002). This study clearly outlines the level of interest in science for elementary grades and identifies overall factors that may influence this level of interest, although it does not discuss the relationship between the frequency with which students are exposed to these factors and their level of interest in these factors. Additionally, Jarvis and Pell (2002) do not distinguish the preferred situational factors across different grade levels and gender.

Surveying over 1000 students between the ages of 8 and 11, Murphy and Beggs (2003) argue that age is the most significant determinant in elementary students' attitudes toward science. This assertion is founded on a marked decline in the enjoyment of school science classes across mid-upper level elementary grades. Surveys complemented by selected pupil-teacher discussions highlighted that elementary science was primarily based on content with very little attention on the assessment of scientific skills and thinking. Students across all ages and of both genders emphasized their preference for “doing” in science class through experimentation. The findings further indicate the importance of social interaction in the science classroom through small group work and team investigations. Disinterest was also associated with repetitive topic revision, lecturing, and note taking associated with the preparation for national tests (in England).

While the study by Murphy and Beggs (2003), situated in the United Kingdom, is comparable with the present study in its use of a mixed-method approach, it does not however touch specifically on the quantitative examination of situational factors that foster the greatest interest in science. The discussion about factors influencing student attitudes toward science are mostly derived from the student-teacher discussions, and not as a result of constructed survey scales. The study carried a stronger focus on the interest in scientific topics as moderated by grade and gender and less on how teachers can best foster interest in the science classroom.

Throughout the review of the literature on science attitudes and interest, the most common methodology used in the collection of data was through the administration of questionnaires largely consisting of Likert-scale items. Studies using attitude scales, such as Murphy and Beggs (2003), have gauged student attitudes toward science through statements such as: “Science lessons are fun” and “I look forward to science lessons.” Although there are many advantages to using attitude scales for examining student attitudes toward science, and indeed such scales are used in the present study, this method does have its weaknesses. Instruments in this field of study often suffer from a lack of clarity or a set definition when using the term attitude. For instance, students' attitudes toward science in schools may be very different from those outside of school or toward scientists (Kind et al., 2007). The distinction of exactly what is being measured is often unclear. Accordingly, when there is no clear definition of the construct being measured, care needs to be taken to not combine separate constructs into one scale with the assumption that these constructs are closely related (Osborne et al., 2003). This lack in consistency across different instruments used to examine student attitudes toward science makes it difficult to compare and contrast results across studies. An additional and often overlooked component in the formulation of an effective attitude measure is to properly address construct validity, which in essence outlines the extent to which a scale represents what it claims to represent. Munby (1997) suggests using factor analysis to show that conceptually formulated scales match with empirically produced factors. As a result of the weaknesses often associated with attitude scales, measures used in the current study were carefully created using clearly defined constructs, reliability analyses, and factor analysis, as complemented by the use of qualitative techniques.

While the greatest percentage of studies utilizes quantitative methods in the form of questionnaires, a sub-group of researchers has used qualitative techniques as well. Osborne, a strong proponent and user of this methodology (e.g., Osborne & Collins, 2000), mentions that, while quantitative measures are useful in determining the nature of a problem, these measures are not effective at aiding in a greater understanding of the problem. He also adds that “while such [qualitative] studies are subject to restrictions of their generalizability, the richness of data does seem to give more insight into the origins of attitudes to school science than quantitative methods indicating that both methodologies have value” (Osborne et al., 2003, p. 1059).

Overall, research in attitudes toward science and science interest outline the importance of interest in science achievement, future attitudes and perceptions of science, and the enjoyment of the subject as a whole. While acknowledging the erosion of such interest through schooling as early as Grade 3, investigators have outlined potential factors responsible for the decline. After close examination of these factors, multiple suggestions have been made in the expectation of improving classroom practice in the sciences at all levels. The use of hands-on experiments, content that is meaningful and relevant, social and group activities, novelty items, and competent teacher modelling and direction are all important examples. These suggested practices have all been shown to enhance science learning and are all part of the context/situation driven factors outlined within situational interest as seen in Table 1.

The present study investigates various situational factors used when learning science in the classroom and the perceived frequency at which students were exposed to these factors. Four situational factors were examined: social interaction, active learning tasks (also known as hands-on activities), teacher modelling, and passive learning tasks (also known as textbook or writing-related tasks). These factors were selected as they were the most commonly mentioned in recent literature as key teaching contexts that affect student interest. By investigating these factors, it is the goal of this study to identify which instructional approaches positively impact the development of individual interest in elementary science classrooms. At present no studies were found that compare the frequency of exposure to a situational factor and the level of interest in that factor. Further, no studies identify those situational factors that foster the most interest in science for each of Grades 4, 5, and 6 and whether or not these preferences differ across grades.

The purpose of science education, while often mislabelled, is not uniquely the re-population of the institution of science. It is, however, the development of scientifically literate minds with the capacity to understand issues of increasing importance and complexity. In a world fraught with economic, environmental, medical, and technological challenges, to name a few, scientific literacy is becoming instrumental in the functioning of a healthy democracy. In neglecting the evidence that students are becoming less interested in science and overlooking those factors influencing their attitudes and the development of their interest in science, we are simply setting ourselves up to fail the purposes of science education and potentially disadvantage new generations of global citizens. Therefore, now that research in the fields of interest and elementary science education have substantially developed, it is crucial that science education researchers become more familiar with the growing body of literature on the study of interest. As stated in the most recent review on student attitudes toward science:

> It is somewhat surprising that so little work has been done in the context of science classrooms to identify what are the nature and style of teaching and activities that engage students. For lest it be forgotten, attitudes are enduring while knowledge often has an ephemeral quality. (Osborne et al., 2003, p. 1074)

CHAPTER 3: METHOD

The purpose of this study was to understand interest in the elementary science classroom as affected by different teaching methods. A two-phase design was used with both a quantitative and qualitative component. This mixed-method approach was chosen to examine complementary aspects of the same phenomenon, and to more comprehensively examine the research questions being investigated (Patton, 2002). As outlined by Greene (1989), the mixed-method strategy is likely to produce better results in terms of quality and scope when examining the breadth of the research questions being asked. In this study, the use of complementarity is illustrated through the use of a quantitative questionnaire measuring the level of perceived frequency and interest in science activities, as combined with qualitative interviews to measure the nature of interest in the science classroom as seen through the eyes of six science students. Through the integration and comparison of data collected using varying methodologies, this study sought to provide a clearer and more complete understanding of interest in the science classroom.

The following sections of this chapter outline the methodology used in conducting this study. The chapter begins with a brief description of the ethical clearance processes, followed by the sampling method and a description of the study participants. The measures – both quantitative and qualitative – are discussed as well as the way in which the data were collected. Finally, this chapter outlines the methods used to analyze the data.

Ethical Considerations

Before undertaking this study, it was necessary to obtain ethical clearance from three separate sources. First, the Education Research Ethics Board (EREB) approved and expedited the study for University clearance in June of 2007. The second body, the General Research Ethics Board (GREB), reviewed and granted clearance for the initial application in July 2007. Finally, following a relatively short review period, the study cleared the remaining ethical review stage by the local school board where the study was to be administered in September 2007.

Of the items outlined in the description of the study within the ethics applications, the procedures surrounding consent and confidentiality were emphasized. When recruiting children to participate in research, it is not only necessary to obtain consent from their parents or guardians, but also to advise the participants of their right to withdraw at any time during the administration of the questionnaire or interview, or to have their data removed in the case of interview participants (data could not be removed at a later stage for the students surveyed as the questionnaires were anonymous). Letters of information and consent were distributed to the teachers of all participating classes (see Appendix A), as well as to all parents/guardians of children within those classes who wished to participate in the questionnaire portion of the study (see Appendix B). As part of the parental consent form for participation in the questionnaire component of the study, parents/guardians were presented with the option of allowing their children to be interviewed. From those who expressed interest, participants were randomly selected for the interviews as stratified by age and gender. The parents/guardians of those students were then given another letter of information and consent form regarding the interview procedures (see Appendix C).

With respect to confidentiality, it was outlined that questionnaires would be completed anonymously and would therefore not be linked to interview data. Further, pseudonyms would be used to protect the identity of interview participants.

As a result of longer than expected delays in the administration of the study questionnaires, a research ethics change form was submitted to GREB in November of 2007. This form requested that the participants randomly selected to participate in the interviews be pulled from the pool of 90 completed questionnaires (in November) instead of waiting until all questionnaires had been administered to expedite the data collection process. The change was granted in early December of 2007, and interviews began before the school holiday break.

Data Collection

Sampling Procedures

Following the ethical clearance for the study, school names and contact information were obtained from the school board directory for schools closest to the researcher. Local principals were contacted sequentially on the basis of proximity. All Grade 4-6 teachers in the schools where the principal agreed to participate in the study were approached, and given a letter of information outlining the study and a consent form. The researcher visited participating classrooms to briefly introduce the study to students and distribute the letters of information and consent forms to be sent home. Those students who returned signed consent forms were given the opportunity to participate in the questionnaire portion of the study. This process continued until approximately 200 students participated in the study. This number of participants was selected to provide sufficient statistical power for the analyses. Students selected to participate in the interview component of the study were randomly selected from those who expressed interest on the initial consent form.

Participants

One hundred seventy-eight (178) students between the ages of 9 and 11 years old participated in this study. The sample consisted of 84 females (47.5%) and 93 males (52.5%). The distribution across Grades 4, 5, and 6 was 39 (22.1%), 54 (30.5%), and 84 (47.4%) students respectively. Participants were drawn from 13 different classrooms, in six schools from both rural and urban settings in Eastern Ontario, representing a range of socio-economic status. Three of the 13 classes were in the French Immersion stream; the remaining 10 were English instruction classrooms. School populations ranged from 250 to 500 students. The sample was predominantly Caucasian, although other races were also represented across the study participants. The students sampled in this study were typical of the distribution of the population within the school board. The questionnaires were only administered in English, as was the conducting of all interviews.

As part of the parental consent form for the survey, parents or guardians were given the opportunity to express interest in allowing their children to be interviewed. Of those whose parents expressed interest, six participants were randomly selected for interviews as stratified by age and gender (3 grades by 2 genders). Interviews took place during regularly scheduled science classes within two months after the administration of the questionnaire (to permit return of interview consent forms). Below is a brief description of each interview participant, all names used being pseudonyms.

Will was a Grade 4 student in an urban school. He was interviewed in January and spoke largely about his science experiences throughout the fall. He was quite talkative and easily expanded on each response. Will reported his favourite subjects to be science and math due to the fact that they were related and helped him understand things he didn't know. He mentioned a particular preference for subjects where he could manipulate objects and work at his own pace. Will also identified his least favourite subjects to be languages and writing as he stated: “The ideas are in my head and I just can't find a way to get them onto the paper, and that always stops me.” The interview with Will lasted about 20 minutes.

Addison was a Grade 4 student from an urban school. Before being interviewed she had come directly from a science class where: “We did an experiment about vibrations with a tuning fork, and we also did an experiment about, umh, baking soda and vinegar.” Throughout the interview she seemed quite shy, often fidgeting and tapping her feet under the table. Her comments remained very limited, with little elaboration or development in her responses. Addison mentioned her preferred subjects were art and drama because she liked expressing herself. The subject she preferred the least was math, as it was hard and required a lot of writing. The interview lasted less than 15 minutes.

Calvin was in Grade 5 attending a large urban school. Throughout the interview he was very talkative, often using paper to draw examples he provided or getting up to act something out. Calvin often sat with his hands on the table answering all questions with great detail and suggesting directions and themes of his own. It was necessary to continuously keep him on topic. When asked about his favourite and least favourite subjects, Calvin did not specify any, only mentioning that he enjoyed drawing. The interview lasted about 25 minutes.

Macey was in Grade 5 from a rural school. Throughout the interview she remained shy and only answered direct questions, elaborating very little. There were many long pauses as she thought about an answer or about the questions being asked. When asked about her favourite subjects, she responded by saying: “Art and Gym, but if you are looking for more of an educational subject, I like science the best.” The interview lasted about 15 minutes.

Reed was in Grade 6 attending a rural school. Throughout the interview, he was somewhat talkative but concise. He spoke about topics in science and social studies interchangeably, referring to many in-class experiences. When asked about his favourite subjects, he responded: “Gym and I kinda like math.” His interview lasted about 15 minutes.

Glenda was in Grade 6 enrolled in an urban school. Glenda sat very straight, often smiling while twisting her arms and hands together during the interview. Several times throughout the interview Glenda mentioned that her preferred subjects were science, specifically biology, and art. She also stated that: “Both my parents do biology so I kind of learned that through them, and I really like it.” Glenda was the first of the six participants to be interviewed. Her interview lasted about 20 minutes.

Measures

Through the use of a questionnaire consisting of five sections, the quantitative component sought to describe the strengths and direction of relationships and allow for systematic group comparisons. In this phase, the study sought to understand to what extent differences in teaching contexts related to student interest in science as moderated by gender and grade level (4-6). The qualitative component allowed for the understanding of a particular phenomenon in greater depth and detail. Through the use of semi-structured interviews, this method was used to best capture contextual meaning and changes in an environment (Patton, 2002).

Questionnaire. Questionnaires are a form of data collection that enables researchers to collect large amounts of data in short-time frames and at a low cost. The use of standardized questions allows for ease in comparing responses among individual participants as well as groups of participants. As questionnaires can be solitary and anonymous, they are well suited for the collection of opinions and feelings about topics or issues (Mertens, 2005; Muijs, 2004).

In this study, a Likert-style questionnaire was administered to all students to determine their individual interest in science, as well as their preferred situational factors and the perceived frequency at which they engaged in these situations (see Appendix D). The Likert-type scale is typically used to measure attitudes or beliefs about a topic or set of ideas. It is generally constructed of a list of statements to which a respondent indicates the strength of agreement or disagreement for each. When correctly constructed, the Likert-type scale is a comprehensive and relatively efficient questionnaire format (Thorkildsen, 2005). The questionnaire in this study consisted of 54 self-report items divided into five sections. Four sections contained a list of statements for which the students selected the most appropriate response on a five-point scale (Hansen, 1999). Responses for each statement on the frequency scale ranged from “not at all” to “extremely often,” and on the interest scale from “not at all” to “extremely.” The first section of the questionnaire contained demographic questions about gender and grade level. In the second section of the questionnaire, statements were related to personal interests in science to determine the students’ individual interest in science. Several of these questions were adapted from those reported in Murphy et al. (2006). Individual interest in science was gauged by statements such as: I look forward to science class; I like watching science shows on TV. Some statements were negatively worded such as:

Science is boring, and Science is too hard; the corresponding scores for these statements were later reversed. The third section of the questionnaire consisted of statements related to different types of situational factors used when learning science in the classroom and the perceived frequency at which students were exposed to these factors. Four situational factors were examined: social interaction, active learning tasks, teacher modelling, and passive learning tasks. As outlined by Bergin (1999) and McPhail, Pierson, Freeman, Goodman, and Ayappa (2000), these factors have been identified as key teaching contexts that affect student interest. To increase the accuracy and internal consistency of the responses, four statements relating to each situational factor were constructed. Situational factors were gauged by statements such as: Working with a partner in science class (social interaction); Making things in science (active learning tasks); When my teacher does a science experiment in front of the class (teacher modelling); Doing written work in science class (passive learning tasks). The fourth section of the questionnaire consisted of the same situational factor statements but was used to identify how interested students were in doing each of them. The final section allowed students to indicate their level of interest in a list of science topics. This fifth section was not used in this study as the data collected did not relate directly to the study's research questions. Additionally, not using these data minimized the amount of data being analyzed and reported, given the scope of the study. Due to time constraints the questionnaire was never piloted. The sampling procedure began immediately after the final ethical clearance was received from the school board.

Interviews. Interviews are mechanisms that provide the researcher with a richness of information that is difficult to achieve through other methods of data collection. Interviewing offers the interviewer a deeper understanding of particular processes and perspectives that may otherwise be glossed over. Additionally, interviews are flexible tools allowing the researcher to develop rather than constrain responses. They can also be unpredictable, where the interviewee may offer insights and issues not initially anticipated by the researcher (Patton, 2002; Research Training Initiative [RTI], 2004).

In this study, interviews of selected students followed the questionnaires to outline in greater detail how students across grade levels and of different genders liked learning science and to understand what the students saw as interesting practices and types of activities in the science classroom. Interviews were semi-structured with set questions, although the researcher did pursue aspects related to science interest introduced by the students (see Appendix E).

The principal advantage of the semi-structured interview format is that it allows for comprehensive and systematic data collection across multiple participants as issues to be discussed are outlined from the beginning (Patton, 2002). The more structured component of this format was important to increase the comparability of the interviewee responses, and reduce interviewer biases across interviews (Mertens, 2005). This type of interview also facilitated the organization and analysis of the data (Patton, 2002). This format was particularly suitable for the purposes of this study as it allowed for spontaneity, flexibility, and the construction of a more conversational style, all in the goal of creating a more casual and less intimidating environment.

Interest in science was explored using topics informed by the questionnaire. As part of the interview guide, students were asked to recall the questionnaire activity and some of statements within it. Students were also asked to recall a recent science class and expand on what they did during that session. Interview participants were also asked to put themselves in the place of the teacher, and asked what they would do to make science interesting and fun for their students.

Procedure

The administration of the questionnaires took place in regular classroom settings as well as the school resource rooms during class time. Questionnaires were administered by the researcher. Before the questionnaires were distributed, a brief presentation by the researcher was given to initiate and explain the activity. It was at this time that participants were reminded of their right to withdraw at any time during the course of the activity without any penalty. After the presentation the researcher read each statement out loud throughout the administration of the questionnaire, and maintained a pace that allowed all students to complete the questionnaire together. This approach was undertaken to ensure the inclusion of students with certain disabilities who might not otherwise have been able to complete the questionnaire independently. To enhance reliability, the same material and approach were used in the administration of the questionnaires for all classes. The entirety of the process took between 20 and 30 minutes. No compensation was awarded to the participants of this study.

Interviews took place in a quiet yet public location within each school. Students were given a list of the topics that were to be discussed and informed of their right to withdraw at any time during the course of the interview without penalty. Interviews lasted approximately 20 minutes and were audio recorded.

Data Analysis

All quantitative data were analysed using the Statistical Package for Social Sciences (SPSS) version 15.0. Survey data were first entered and scanned for missing and incorrect entries. Outliers (numbers other than 1 through 5) were identified and corrected. The only outliers identified were as a result of data entry. Prior to the preliminary analysis, all negatively worded statements within the questionnaire were reversed.

Preliminary Analysis

This stage of the analysis consisted of the computation of descriptive statistics. For each variable, the mean (M) and standard deviation (SD) were calculated to outline general trends and indicate the spread of the data.

Factor analysis was then performed to identify patterns in the correlations among variables (Vogt, 2007). These patterns were used to create sub-scales for each situational interest factor, frequency factor, and to refine the individual interest scale. Factors were determined using the principal axis factoring method, as it is most commonly used for exploratory analysis in the social sciences (Vogt, 2007). A Direct Oblimin rotation was used to improve the interpretability of the solution output, as it is assumed that underlying processes are correlated (Tabachnick & Fidell, 2007, p. 639). Additionally, a factor loading cut-off of 0.45 was selected to maintain a significant percentage of variance, in line with other social science research (Vogt, 2007). Following factor analysis and the creation of sub-scales, the reliability of each scale was calculated. Represented by the Cronbach's alpha coefficient, reliability indicates the internal consistency of a given scale (Field, 2005).

Main Analyses

Research Question #1: To what extent do grade and gender relate to situational interest, factor frequency, and individual interest? To answer the first research question, a 2 (gender) x 3 (grade) multivariate analysis of variance (MANOVA) was used. MANOVA is used to test whether or not mean differences among groups on a combination of dependent variables are likely to have occurred by chance (Tabachnick & Fidell, 2007). One of the main advantages of using MANOVA is protection against inflated Type 1 error (finding a significant result when it is not, in fact, significant) caused by multiple tests of correlated dependent variables. MANOVA also considers the relationship between variables not measured by separate ANOVA tests (Tabachnick & Fidell, 2007). For this research question, situational interest factor scales and situational factor frequency scales served as dependent variables, while the independent variables included gender and grade level. Multivariate effects were assessed with the Wilks' Lambda criterion, and subsequent univariate and Bonferonni post-hoc tests were carried out for significant results to determine specific sources of variance.

Post-hoc tests are used to locate particular independent variables responsible for the overall significant F test. In this type of test, also known as a pairwise comparison, each pair of treatments is compared to determine which pair or pairs are significantly different from one another (Steinberg, 2008, p. 293). For these analyses the Bonferonni procedure was used for pairwise comparisons. This test was selected for its flexibility and its ability to control type 1 error (Field, 2005).

Additionally, a univariate analysis of variance was conducted with the individual interest scale to determine whether or not grade level and gender related to individual interest. The minimum level of significance (alpha) was set at 0.05 for all statistical tests.

Research Question #2: To what extent do factor frequency and situational interest factors relate to each other? The second question examined the correlations between the situational interest factor scales and the situational factor frequency scales. A correlation coefficient is a measure of (statistical) association between two variables, and determines the strength of this relationship (Vogt, 2007). For the purpose of this question, a Pearson correlation was used as it indicates the degree that two continuous variables are linearly related.

Research Question #3: To what extent do different situational interest factors and factor frequency relate to student interest in science, as moderated by grade level (4-6) and gender? To answer the third research question, a multiple linear regression was performed to examine the extent to which grade level, gender, situational interest, and factor frequency were significant predictors of individual interest in science.

Multiple linear regression examines the relationship between a dependent variable and two or more independent variables. Regression analysis is used to determine whether or not the independent variables are predictors of the outcome or dependent variable. A distinct advantage of multiple regression is that it is able to determine the relative contributions of each predictor by taking into account correlations between predictor variables (Muijs, 2004).

For the purpose of this question two sets of regression analyses were performed. The first used the enter method to identify which group of predictors best correlated with the criterion variable. As the goal was to simply assess the relationships among variables with no theoretical model in mind, it was deemed most appropriate to use the enter method for multiple regression (Tabachnick & Fidell, 2007). Serving as blocks of independent variables were gender and grade, situational frequency factors, and situational interest factors. Individual interest in science served as the dependent variable. In the second set of analyses the statistical (stepwise) regression method was used to determine the strongest predictors of individual interest in science for each gender and grade. The stepwise method is often used to develop a group of independent variables useful in predicting the dependent variable, and eliminate those independent variables that do not contribute to the prediction equation. This technique is typically used in exploratory analyses as the statistics generated from the sample data control the order of entry of variables (Tabachnick & Fidell, 2007). The dependent or criterion variable in this analysis consisted of individual interest in science. The independent or predictor variables included situational interest factor scales and situational factor frequency scales for each gender and grade.

Research Question #4: What makes for interesting and effective teaching of science in the eyes of the students? To answer this research question thematic development was undertaken through qualitative analysis to gain an in-depth understanding of the central phenomenon. As mentioned by Creswell (2008), qualitative analysis is an inductive process, transitioning from detailed data to general codes and themes. Initial analyses consisted of subdividing data with the goal of generating a larger consolidated picture. To organize and analyze the transcription data, a coding system was developed where text was segmented and labelled to form descriptions and general themes in the data (Tesch, 1990).

> The object of the coding process is to make sense out of text data, divide it into text or image segments, label the segments with codes, examine codes for overlap and redundancy, and collapse these codes into broad themes. (Creswell, 2008, p. 251)

For this study six interviews were transcribed verbatim and read separately. Transcripts were thematically coded by assigning units of data to different categories. A deductive approach was utilized when reviewing the data for the first time. This approach allowed for the initial themes to be created under the heading of each situational factor: active learning tasks, social interaction, teacher modelling, and passive learning tasks. It became quite easy to identify discussion and statements regarding these four situational factors. Another theme also emerged that was not initially expected. As part of student answers to prescribed questions and through tangential remarks, each interview participant alluded to a certain characteristic quality of the subject of science. They spoke of a fascination in discovering the unknown. This became a fifth category called the Joy of Discovery. Other categories were initially created outlining students' recommendations to science teachers, and another highlighting each student's rationale behind her or his interests. These categories were later collapsed into the situational factor categories to streamline the data and better organize each category.

Coding began by assigning each category a colour and reading through each transcript, highlighting relevant statements associated with each category. For example, the colour yellow was used to highlight all references made to Active Learning Tasks. This process required multiple trials before each transcript was sufficiently coded. Following the first coding process, each highlighted statement from each transcript was transferred to a designated file for each category. In other words, all yellow coloured statements were inputted into the Active Learning Tasks file. Once this re-distribution was complete, statements within each category file were colour-coded a second time for emerging sub-themes. After this second analysis of the transcription data was finalized, each theme was reported as seen in the qualitative section of the results chapter.

CHAPTER 4: RESULTS

This chapter presents the results of the data analysis described in the method chapter. It is divided into three main sections. The first section outlines the preliminary quantitative results, which include: descriptive statistics, factor analysis, and reliability estimates. The second section describes the main quantitative results in three sub-sections representing the first three research questions: 1. To what extent do grade and gender relate to situational interest, factor frequency, and individual interest?; 2. To what extent do situational frequency and situational interest factors relate to each other?; 3. To what extent do different situational interest factors and factor frequency relate to student interest in science, as moderated by grade level (4-6) and gender? The final section discusses the qualitative results stemming from the study's fourth research question: 4. What makes for interesting and effective teaching of science in the eyes of the students?

Preliminary Quantitative Results

Descriptive Statistics

Before undertaking preliminary analysis, the questionnaire data were scanned for missing responses that might have been caused by unclear or poorly worded statements. A total of seven questionnaires contained missing responses. Only one questionnaire was removed from further analysis as one of its sections had not been completed. The six remaining questionnaires were included as the missing responses in each were related to items removed from the appropriate scale as a result of poor factor loading (see section on factor analysis). Therefore, these missing responses did not affect the inclusion and analysis of these questionnaires.

A total of 177 study questionnaires were used for the data analysis. The distribution of completed questionnaires is presented in Table 2. Both genders were fairly equally represented with 47.5% of respondents being male and 52.5% being female. The distribution of respondents by gender was fairly equal across grades for females; however this was not the case for boys, with only 40.5% of male respondents from Grades 4 and 5, and the remaining 59.5% from Grade 6. Similarly, total student responses were also unequal across grades with a distribution of 22.1%, 30.5%, and 47.4% for Grades 4 through 6 respectively.

Table 2
Distribution of Participants (n = 177)

	Male	Female	
Grade	Frequency	Frequency	Total (%)
4	13	26	39 (22.1)
5	21	33	54 (30.5)
6	50	34	84 (47.4)
Total (%)	84 (47.5)	93 (52.5)	177 (100)

The mean, standard deviation, skewness, and kurtosis for each of the 42 variables in the questionnaire are presented in Appendix F. To determine if the data were normally distributed the skewness and kurtosis were analysed. Skewness is related to the symmetry of the data distribution. A skewed variable is one whose mean is not at the centre of the data distribution. Thus variables can either be positively or negatively skewed. Kurtosis is a measure of how peaked or flat the distribution is (Tabachnick & Fidell, 2007). Both skewness and kurtosis were evaluated by referring to the guidelines presented in Tabachnick and Fidell (2001), where values within -1 and 1 would indicate that the data are normally distributed. Questionnaire variables proved to be normally distributed on the whole, with the exception of “Doing science experiments” and “Making things in science,” which were skewed severely negatively and had high kurtosis values. As a result, three options were considered. The first option was to transform the two interest variables, although doing so would place these items on a different metric than the remaining 13 variables slated to form the interest scales. The second option was to omit the two variables; however, since the two were from the same scale, this option would have left only two other variables to construct the scale, thereby reducing its reliability. Thus, as a result of these concerns, the third option was chosen, which was to keep the two skewed variables and allow them, along with two normally distributed variables, to form the scale for active learning tasks.

Subsequently, data were checked for univariate and multivariate outliers through the calculation and examination of z-scores. As outlined by Tabachnick and Fidell (2007), scores exceeding 3.29 ($p < .001$, two-tailed test) would be considered potential outliers, especially if the sample size is small. No z-scores exceeded this limit; therefore all responses were kept.

Factor Analysis

Factor analysis was performed for each of two sections of the study questionnaire. The first section included eight variables measuring participant's individual interest in science. The second section included 16 variables measuring participant interest for each of the situational factors.

Before undertaking the factor analysis, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were calculated. The KMO indicates the reliability of the relationships between pairs of variables. Values of at least 0.6 are required for a suitable factor analysis (Tabachnick & Fidell, 2007). Values achieved in the individual interest and situational interest analyses were .88 and .81 respectively, suggesting that factor analysis should render distinct and reliable factors.

Bartlett's test of sphericity measures whether a correlation matrix is proportional to an identity matrix, which is to say whether diagonal items, or group variables, in the matrix are equal. The purpose of this test is to examine if the variables are unrelated and therefore if factor analysis is a suitable method to pursue. A significance level of 0.05 or less is considered to be satisfactory for this test (Field, 2005). Data in this study produced values of χ^2 (28) = 563.60, $p < 0.001$ and χ^2 (120) = 1116.89, $p < 0.001$ for the individual interest and situational interest analyses respectively, and were therefore significant.

All variables intended for each scale were entered into a principal axis factor analysis. Two factors were extracted for the individual interest analysis and four factors extracted for the situational interest analysis. All factors were rotated following the direct oblimin criterion. This method was chosen as it permits correlation between factors and is commonly used when examining psychological constructs (Field, 2005). Rotated factor loadings from the pattern matrix for the individual interest variables are presented in Table 3 and accounted for 63.87% of the variance. Similarly, rotated factor loadings from the pattern matrix for situational interest are displayed in Table 4 and accounted for 64.19% of the variance. Each table also presents eigenvalues, individual variance explained, and accumulated variance explained.

Following the criterion outlined in Vogt (2007), items with factor loadings of 0.45 were maintained within the pattern matrices. As observed in Table 3, six of the eight items met this criterion and loaded within the two individual interest factors. The two items that did not load were: “I like watching science shows on TV,” and “It is very important to learn about science,” and were therefore deleted. The first factor hosted five of the items and the second only one. As the goal of conducting this analysis was to identify a pattern among variable correlations and create a scale for individual interest in science, the second factor was eliminated, and the scale was created with the five items within the first factor. Within the pattern matrix for situational interest in Table 4, 15 of the 16 items loaded within the four factors. The item that did not load was: "Talking and sharing our ideas about a science topic," and this item was therefore deleted. Factors 1, 2, and 4 were defined by four variables, and factor 3 by three variables without any cross-loadings. All four factors were kept to form four scales for situational interest.

The factor structure for the situational frequency factors initially produced four factors. The composition of these factors ranged from one variable to six variables. These

Table 3
Two-factor Rotated Component Matrix for Individual Interest Variable

Item		Factors	
		1	2
8	Science is fun	.83	
4	Science is boring	.79	
2	I like science	.75	
1	I look forward to science class	.70	
7	Science is too hard	.54	
6	I enjoy science books or articles		.70
	Eigenvalue	4.01	1.04
	Variance explained (%)	50.12	12.96
	Accumulated variance explained (%)	50.12	63.87

Table 4

Four-factor Rotated Component Matrix for Situational Interest Variables

Item		Factor 1	2	3	4
7	Watching my teacher do a demonstration	0.80			
13	Watching my teacher do a science experiment in front of the class	0.77			
4	Watching my teacher show me things in science	0.72			
15	Looking at things my teacher brings into the class for science	0.46			
10	Making things in science		0.81		
1	Doing science experiments		0.73		
16	Working with my hands in science class		0.72		
6	Measuring things and using special tools when doing science		0.51		
5	Exploring and working on science with others			-0.78	
2	Working with a partner in science class			-0.78	
12	Working on science projects as a group			-0.62	
3	Doing written work in science class				0.91
8	Working on handouts in science class				0.76
14	Copying things from the board in science class				0.56
11	Reading about science in class				0.53
	Eigenvalue	4.74	2.71	1.60	1.22
	Variance explained (%)	29.63	16.96	9.98	7.62
	Accumulated variance explained (%)	29.63	46.59	56.57	64.19

factors did not match the situational interest factors in terms of item loadings. As a result of the uneven variable distribution, low factor loadings, and the mismatch between situational interest and situational frequency, this situational frequency factor structure was not utilized. Therefore, to more accurately compare situational factor frequency with the four scales created for situational interest, four scales were created for the situational frequency factors replicating the construct of each situational interest scale. The choice to mirror the scale construction was largely based on the examination of correlations between the frequency and interest factor scales as part of the second research question.

In the remaining sections of the results chapter and for the discussion chapter, Factor 1 for individual interest is referred to as individual interest. Factor 1 for situational interest is referred to as Teacher Modelling, Factor 2 as Active Learning Tasks, Factor 3 as Social Interaction, and Factor 4 as Passive Learning Tasks.

Reliability Estimates

Using the Cronbach's alpha statistic, the internal consistency of each subscale was measured. This analysis was performed to measure whether or not different items within each subscale, created using factor analysis, were measuring the same general construct.

Reliability estimates for individual interest and situational interest subscales are presented in Table 5, and situational factor frequency subscales are presented in Table 6. As indicated by Field (2005), Cronbach's alpha values greater than .7 are generally accepted when measuring psychological constructs. The values obtained for the questionnaire subscales for interest were all greater than .78 and were therefore acceptable and interpreted as internally consistent. However, the values obtained for the factor frequency subscales ranged from .35 to .63 and were therefore much less reliable.

Table 5

Reliability Estimates for Interest Subscales

Subscales	Number of items	Items used within scales	Cronbach's Alpha
Individual Interest	5	1, 2, 4, 7, 8	0.86
Teacher Modelling	4	4, 7, 13, 15	0.80
Active Learning Tasks	4	1, 6, 10, 16	0.78
Social Interaction	3	2, 5, 12	0.78
Passive Learning Tasks	4	3, 8, 11, 14	0.80

Table 6

Reliability Estimates for Frequency Subscales

Subscales	Number of items	Items used within scales	Cronbach's Alpha
Teacher Modelling	4	4, 7, 13, 15	0.61
Active Learning Tasks	4	1, 6, 10, 16	0.63
Social Interaction	3	2, 5, 12	0.61
Passive Learning Tasks	4	3, 8, 11, 14	0.35

Main Quantitative Analyses

Research Question #1: To what extent do grade and gender relate to situational interest, factor frequency, and individual interest?

Situational Interest Factors: Comparisons by Gender and Grade. A 2 (gender) x 3 (grade) between-subjects multivariate analysis of variance (MANOVA) was conducted on the four situational interest factor subscales: Teacher Modelling, Active Learning Tasks, Social Interaction, and Passive Learning Tasks. Independent variables were gender and grade. The Wilks' Lambda multivariate test of overall differences among groups was found to be statistically significant for gender, F (4, 169) = 2.55, p = 0.041, partial η^2 = 0.057. No significance was found for grade or across the interaction of both gender and grade.

Given the significance of the MANOVA for gender, univariate between-subjects tests were performed. These tests revealed that gender was significantly related to interest in passive learning tasks, F (1, 172) = 5.24, p = 0.023, partial η^2 = 0.030. As indicated in Table 7, female students displayed a significantly greater interest in passive learning tasks in science than male students (*M*s= 2.58, 2.24, respectively).

Situational Frequency Factors: Comparisons by Gender and Grade. A 2 (gender) x 3 (grade) between-subjects MANOVA examined associations between the four dependent variables: Teacher Modelling Frequency, Active Learning Tasks Frequency, Social Interaction Frequency, and Passive Learning Tasks Frequency. Independent variables consisted of gender and grade. Using the Wilks' Lambda criterion the combined dependent variables were found to be significantly affected across grade, F (8, 338) = 2.58, p = 0.01, partial η^2 = 0.058 and across the interaction of both gender and grade, F (8, 338) = 3.17, p = 0.002, partial η^2 = 0.070.

Univariate testing revealed significant grade differences for Teacher Modelling Frequency, F (2, 171) = 3.65, p = 0.028, partial η^2 = 0.041, although not for any of the other situational frequency factors (see Table 8). The interaction between gender and grade was found to be significant only for the Frequency of Passive Learning Tasks, F (2, 171) = 5.56, p = 0.005, partial η^2 = 0.061. Subsequent to the univariate tests, Bonferroni post-hoc comparisons were performed revealing no statistical significance. This test was undertaken to see where (what grade) significant differences might exist.

Individual Interest: Comparisons by Gender and Grade. To examine the effect of gender and grade on individual interest in science, a univariate analysis of variance (ANOVA) was conducted. The analysis revealed that none of gender, grade, or the interaction effect between grade and gender had a significant effect on individual interest in science (see Table 9).

Research Question #2: To what extent do situational frequency and situational interest factors relate to each other?

A correlational analysis was conducted to determine the strength of the relationships, if any, between the situational frequency and interest subscales (see Table 10). The Pearson product-moment correlation coefficient was used in this analysis to examine the degree to which the subscales were linearly related.

While multiple subscales displayed a significant relationship, most correlations resulted in Pearson correlation coefficients of less than .30. Correlations between frequency and interest sub-scales for each situational factor revealed only two significant relationships. The frequency of student exposure to Teacher Modelling and student interest in Teacher Modelling were correlated at r = .18, and the frequency of social interaction and interest in social interaction were correlated at r = .39. The relationships between the perceived frequency of exposure and interest for both active and passive learning tasks were not significant.

Sub-scales were observed to correlate significantly within their respective frequency and interest groups barring two exceptions. All frequency sub-scales correlated significantly with one another with the exception of the frequency of teacher modelling and the frequency of passive learning tasks. Significant correlations ranged from $r = .21$ (frequency of teacher modelling and active learning tasks) to $r = .32$ (frequency of social interaction and active learning tasks). Similarly, all interest sub-scales correlated significantly among themselves with the exception of interest in active learning tasks and interest in passive learning tasks. Significant correlations ranged from $r = .21$ (interest in social interaction and passive learning tasks) to $r = .50$ (interest in teacher modelling and passive learning tasks).

Table 7

Means and Standard Deviations for Situational Interest Subscales by Gender and Grade

	Grade 4 ($N = 39$)	Grade 5 ($N = 55$)	Grade 6 ($N = 84$)	Male ($N = 85$)	Female ($N = 93$)	Univariate Results for Gender	
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*F*	partial η^2
TM	3.40 (.61)	3.35 (.82)	3.31 (.86)	3.27 (.81)	3.40 (.78)	1.01	0.01
ALT	4.20 (.71)	4.24 (.57)	4.14 (.77)	4.26 (.67)	4.11 (.72)	1.79	0.01
SI	3.84 (.95)	3.84 (.83)	3.93 (.74)	3.79 (.91)	3.96 (.72)	1.97	0.01
PLT	2.54 (.90)	2.48 (.89)	2.31 (.82)	2.23 (.82)	2.58 (.87)	5.24*	0.03

Note. TM = Teacher Modelling, ALT = Active Learning Tasks, SI = Social Interaction, PLT = Passive Learning Tasks.

* $p < .05$

Table 8

Means and Standard Deviations for Situational Frequency Subscales by Gender and Grade

	Grade 4 (*N* = 39)	Grade 5 (*N* = 55)	Grade 6 (*N* = 84)	Univariate Results for Grade		Male (*N* = 85)	Female (*N* = 93)
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*F*	partial η^2	*M* (*SD*)	*M* (*SD*)
TMF	3.24 (.74)	2.89 (.74)	3.02 (.71)	3.65*	0.04	2.99 (.73)	3.06 (.73)
ALTF	2.78 (.54)	2.77 (.64)	2.65 (.78)	0.65	0.01	2.68 (.71)	2.75 (.68)
SIF	2.72 (.73)	2.97 (.75)	2.73 (.77)	1.57	0.02	2.69 (.71)	2.90 (.80)
PLTF	3.43 (.62)	3.72 (.62)	3.55 (.61)	2.17	0.03	3.60 (.58)	3.56 (.66)

Note. TMF = Teacher Modelling Frequency, ALTF = Active Learning Tasks Frequency, SIF = Social Interaction Frequency, PLTF = Passive Learning Tasks Frequency.

* $p < .05$, ** $p < .01$

Table 9

Means and Standard Deviations for Individual Interest Subscale by Gender and Grade

	Grade 4 (N = 39)	Grade 5 (N = 55)	Grade 6 (N = 84)	Male (N = 85)	Female (N = 93)
	M *(SD)*	*M* *(SD)*	*M* *(SD)*	*M* *(SD)*	*M* *(SD)*
II	3.82 (.82)	2.97 (.70)	3.83 (.87)	3.88 (.87)	3.86 (.75)

Note. II = Individual Interest

Table 10

Bivariate Correlations among Subscales (N = 177)

	1	2	3	4	5	6	7
1. TMF	-						
2.ALTF	.21**	-					
3. SIF	.30**	.32**	-				
4.PLTF	.14	.25**	.28**	-			
5. TM	.18*	.24**	.14	.18*	-		
6. ALT	.03	.12	.01	.23**	.26**	-	
7. SI	.27**	.23**	.39**	.28**	.26**	.35**	-
8. PLT	.23**	.21**	.20**	.12	.50**	.08	.21**

Note. TMF = Teacher Modelling Frequency, ALTF = Active Learning Tasks Frequency, SIF = Social Interaction Frequency, PLTF = Passive Learning Tasks Frequency, TM = Teacher Modelling, ALT = Active Learning Tasks, SI = Social Interaction, PLT = Passive Learning Tasks.

* $p < .05$, ** $p < .01$

Research Question #3: To what extent do different situational interest factors and factor frequency relate to student interest in science, as moderated by grade level (4-6) and gender?

To answer this research question, two sets of regression analyses were performed. The first used the enter method to identify which group of predictors best correlated with the criterion variable. Serving as blocks of independent variables were gender and grade, situational frequency factors, and situational interest factors. The scale for individual interest in science served as the dependent variable.

Model 1 was comprised of gender and grade inputted as the first block. This model did not prove to be significant and accounted for less than 1% of the variance. Model 2a was constructed with the variables from block 1 and the situational frequency factors as block 2. This model was also insignificant and accounted for 3.3% of the variance. Model 2b was composed of the block 1 variables and the situational interest factors as a block. This model proved significant at ($F_{7,169} = 11.66$, $p < .001$), and accounted for 32.6% of the variance. Model 3 included all blocks ($F_{11,165} = 7.53$, $p < .001$) and accounted for 33.4% of the variance. As evidenced by the significance of Model 2b and Model 3, the block composed of the situational interest factors had the strongest effect on the prediction of individual student interest in science (see Table 11).

In the second set of analyses the stepwise method was used to determine the strongest predictors of individual interest in science for each gender and grade (4-6). The eight subscales representing the frequency and interest factors were used as independent variables. The dependent variable remained the scale for individual interest in science.

Table 11

Enter Method Regression of Factors Predicting Individual Interest

Model	Model 1	Model 2a	Model 2b	Model 3
		β		
Gender	-.017	-.032	-.083	-.089
Grade 5	.083	.096	.087	.108
Grade 6	.003	.022	.047	.057
TMF		.112		.020
ALTF		.071		-.018
SIF		.060		.015
PLTF		.012		-.096
TM			.004	.014
ALT			.246***	.262***
SI			.128	.139
PLT			.430***	.431***
R^2	.006	.039	.326	.334
ΔR^2	.006	.033	.320	Model 2a = .301 Model 2b = .014
F	.380	.990	11.66***	7.53***

Note. TMF = Teacher Modelling Frequency, -ALTF = Active Learning Tasks Frequency, SIF = Social Interaction Frequency, PLTF = Passive Learning Tasks Frequency, TM = Teacher Modelling, ALT = Active Learning Tasks, SI = Social Interaction, PLT = Passive Learning Tasks.

*** $p < .001$

For male students, Social Interaction and Passive Learning Tasks emerged as the only significant predictors ($F_{2,81} = 15.34$, $p < .001$). As shown in Table 12, the value of R^2 was .26, which indicated that together the two predictors accounted for 26% of the total variance in individual science interest. The examination of the R^2 statistic at each step within the stepwise regression analysis identifies the proportion of variance that each variable contributes. Results from the regression among female students revealed Passive Learning Tasks and Active Learning Tasks to be the only factors to significantly predict individual science interest ($F_{2,90} = 33.12$, $p < .001$; see Table 13). These predictors accounted for 41% of the total variance in individual science interest, which was a larger proportion of the variance than the predictors among male students.

As outlined in Table 14, for Grade 4 students, Passive Learning Tasks and Teacher Modelling were the only significant predictors of individual science interest ($F_{2,36} = 19.94$, $p < .001$). The .50 value of R^2 indicated that together the two predictors accounted for 50% of the total variance in individual science interest. The regression analysis among Grade 5 students shown in Table 15 revealed Passive Learning Tasks and Active Learning Tasks to be the only factors as significant predictors ($F_{2,51} = 16.41$, $p < .001$). The two predictors accounted for 37% of the total variance in individual science interest. Lastly, results from the regression of predictive factors among Grade 6 students revealed Active Learning Tasks and Passive Learning Tasks to be the only factors to significantly predict individual science interest ($F_{2,81} = 10.81$, $p < .001$). As outlined in Table 16, the .19 value of R^2 indicated that together the two predictors accounted for 19% of the total variance.

Table 12
Stepwise Regression of Factors Predicting Individual Interest among Male Students

Model	Factor	β	R^2	F	ΔR^2
1	SI	0.45***	0.19***	20.27	
2	SI	0.39***	0.26***	15.34	0.07**
	PLT	0.38**			

Note. SI = Social Interaction, PLT = Passive Learning Tasks.

** $p < .01$, *** $p < .001$

Table 13
Stepwise Regression of Factors Predicting Individual Interest among Female Students

Model	Factor	β	R^2	F	ΔR^2
1	PLT	0.59***	0.34***	47.43	
2	PLT	0.55***	0.41***	33.12	0.07**
	ALT	0.29***			

Note. PLT = Passive Learning Tasks, ALT = Active Learning Tasks.

** $p < .01$, *** $p < .001$

Table 14
Stepwise Regression of Factors Predicting Individual Interest among Grade 4 Students

Model	Factor	β	R^2	F	ΔR^2
1	PLT	0.67***	0.43***	30.00	
2	PLT	0.50***	0.50***	19.94	0.07*
	TM	0.33*			

Note. PLT = Passive Learning Tasks, TM = Teacher Modelling.

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

Table 15

Stepwise Regression of Factors Predicting Individual Interest among Grade 5 Students

Model	Factor	β	R^2	F	ΔR^2
1	PLT	0.55***	0.29***	22.70	
2	PLT	0.55***	0.37***	16.41	0.08**
	ALT	0.30**			

Note. PLT = Passive Learning Tasks, ALT = Active Learning Tasks.

** $p < .01$, *** $p < .001$

Table 16

Stepwise Regression of Factors Predicting Individual Interest among Grade 6 Students

Model	Factor	β	R^2	F	ΔR^2
1	ALT	0.37***	0.12***	12.76	
2	ALT	0.33***	0.19***	10.81	0.07**
	PLT	0.28**			

Note. ALT = Active Learning Tasks, PLT = Passive Learning Tasks.

** $p < .01$, *** $p < .001$

Qualitative Results

In this section, five themes are presented. Four themes were constructed from the situational factors explored in the questionnaire: Active Learning Tasks, Social Interaction, Teacher Modelling, and Passive Learning Tasks. The fifth theme emerged as a result of transcript analysis and related to the fascination experienced by students when discovering the unknown about scientific topics. This theme was called the Joy of Discovery. Within each theme, comments from each of the six participants are reported and briefly discussed. As evidenced in the quantitative section, on average, participants held a significantly greater amount of interest for Active Learning Tasks (M = 4.18, SE = .05), than for Social Interaction (M = 3.88, SE = .06, $t(177)$ = 4.64, $p < .001$), for Social Interaction (M = 3.88, SE = .06), than for Teacher Modelling, (M = 3.34, SE = .06, $t(177)$ = -7.33, $p < .001$) and for Teacher Modelling (M = 3.34, SE = .06), than for Passive Learning Tasks (M = 2.41, SE = .06, $t(177)$ = 14.95, $p < .001$). The four themes are presented in this order followed by the emerging theme, Joy of Discovery.

Active Learning Tasks

When asked about past experiences in science class, all students reported exposure to various active learning tasks. Glenda (Grade 6) described how “we did a bit of stuff on flight, and we built paper airplanes and started testing them in different ways to see how they worked. Different planes did different things during flight.” Reed (Grade 6) stated: “Sometimes they (the teachers) will bring in samples like batteries and then they'll show us how to connect all the wires and then they'll bring in other stuff and they'll just show us how to do it.” Macey (Grade 5) outlined a similar type of experience where she described an experiment from her anatomy unit, explaining:

> We were doing the respiratory system, we got to do an experiment and you take a bucket of water and you put like a.... take a 4L bottle and you fill it with water and fill the tub with water and you put it like down and then you put a tube up it and you have a straw and you see how much your lungs can hold, it was cool. Different people got to do it, so you learned how different people have different lung capacities.

Comparable to Macey's explanation, each of the other interview participants identified their experiences as positive, saying: “We made posters and just had really fun doing it” (Reed). “We did water centres at one point ... and I had a lot of fun doing it and thought we should have done it again but we haven't gotten around there yet” (Will, Grade 4). “One time she (the teacher) took a balloon and had everybody take one and rub it on their head and took salt and pepper, and it sounded like it was raining, and it was really cool” (Calvin, Grade 5).

After discussing past science classroom experiences and activities, students were asked about what makes science classes or topics interesting. There was no interview where this question remained unanswered; often students came back to this question throughout the interview to add more detail to each of their explanations. The overarching theme in their responses emphasized the use of experiments and the manipulation or creation of objects. Calvin highlighted this idea by mentioning: “Science class is interesting with projects. If you are doing an experiment/project or something that was brought out in an interesting way to you, that you get excited about it, and do something that is really cool about it.” Both Glenda and Reed supported this view. “Stuff that’s hands-on with anything like what we did about the airplanes and make it a lot more interesting and we really get to see it in real life, instead of reading it out of a textbook. I like to do things hands-on in science” (Glenda). “They can like, sometimes bring in samples, that really helps a lot. Sometimes they'll show you what to do and you can go ahead and do it” (Reed).

Of those participants who stated that active learning tasks made science class interesting and engaged them in the learning experience, Will, Calvin, and Glenda expanded upon their responses and described the rationale behind this engagement. Will outlined his rationale in the following way:

> To me it makes you learn a little bit more because when you're watching the teacher all the time ... you don't really get it. You can see it but you're kind of thinking that ... well if I was doing this what different things could I do to make it work and it... always makes me feel better if I can do it so I can actually experiment a little bit more with what we are doing.

Calvin suggested: “Umh, I think it's better to do the experimenting. It attracts attention to science.” Lastly, in Glenda's opinion: “Doing stuff yourself, that is my best way of learning science, doing everything yourself and trying things out for yourself.”

All students, when asked what they would do in the shoes of their teachers or if they had any suggestions for those who taught them science, had recommendations to give with respect to the use of active learning tasks. Glenda said she “would do something that was really visual because in my opinion that really attracts your attention more than a textbook; it would be something you really see.” Macey mentioned: “Pretty much with experiments, and as you do the experiments kind of like telling the kids how it works as you do it.” This recommendation was also reflected in conversation with the other participants: “Do experiments with your hands and sometimes watch Bill Nye” (Addison, Grade 4). “Experiments, a lot of experiments ... I think those are the main things that I would say would help a lot of students work” (Will). Both Addison and Will, the two Grade 4 students, stated that they enjoyed watching Bill Nye the Science Guy because “he is really funny doing it... and he does a lot of experiments” (Will). They also suggested that all science students should have the opportunity to view this program in class.

Overall, each participant had a positive reflection of active learning tasks in science. The frequency at which they were exposed to this type of situational factor did not seem to inhibit their ability to speak about it and recommend this type of strategy for further use. The boys often had more to say about their experiences and the use of active learning tasks in class, whereas the girls were more apt to label their experiences as positive and not provide as much detail.

Social Interaction

When asked about their experiences working with classroom colleagues, all students were quick to list advantages. Some students even brought the topic up themselves while discussing past in-classroom science experiences. The majority of the benefits of working with others came down to helping one another out. As Glenda described it: “With your friends if you really don’t understand, your friends might understand, so when you’re working together you can help each other understand different parts.” Similarly, Addison and Reed mentioned how group colleagues often served as a helpful resource. Addison reported that “Sometimes if I get stuck and I don't know something they can help me.” Reed supported this idea by adding that “If you get stuck then your friend can show you what to do, and that just helps you a lot.” An additional advantage cited by Will was the generation of different ideas.

> It is a lot of fun working as a team because you can actually share your ideas with other people. That is the other thing I really like about it. If I can share my ideas and they can share their ideas with me it kind of is easier to work together and find out what the actual ... the answer.

Also quick to point out the advantages was Calvin, although he added that group work can sometimes prove distracting and counterproductive as well. When speaking about working with others, he stated:

> I think it's better because then it gives you more confidence and you have a bigger brain, like two brains are better than one, unless they don't work together. If they don't work together then I would say that it is best to have that person work with another friend.

When asked about this type of situation, Calvin reminisced on two separate occasions where he worked with “too close a friend” versus just another classmate saying: “I got twice the mark I would have gotten with ... my friend.”

Two students made explicit recommendations for the use of social interaction. Reed tied his recommendation to one of the advantages listed above, saying: “I would let them work with a partner, because I think that helps a lot, just to work with a partner 'cause if you don't get it your partner may, and he can show you and then you'll get it.” Glenda made a similar recommendation, adding that the benefit of strategically pairing students might help engage more of them in the topic at hand. She suggested:

> I would do something that was really visual and do something, that way they could work together with people who really enjoy science maybe with people who didn’t enjoy it so much so they could learn the fun side of science.

In addition to concurring that in classwork partners were a helpful resource, Addison expanded again on her reasoning behind being engaged by “Bill Nye the Science Guy.” She highlighted that “Sometimes he has kids on his show; he had kids do the experiments.” When asked about this reasoning, she explained that the interaction among the kids helped her relate to science better.

Teacher Modelling

While all interview participants spoke to the topic of teacher modelling, it was mostly the boys who discussed this situational factor at length. The girls more commonly responded by asserting that it was “a good way too” or by mentioning that they liked it when teachers modelled a particular activity for them.

Descriptions of teacher modelling during lessons ranged from brief statements that acknowledged the approach such as: “We did a couple experiments, but it was mostly the teacher that did them” (Will), to more detailed specifics such as Calvin's:

> Static electricity was a really fun thing. I remember she (the teacher) would go like this on the carpet and say “OK now who wants to be shocked,” and we were like “me me me,” and we would start chasing her around the room, and then she touched the desk and said, “Why did I do this?” and we were like “umh.” She explained all about static electricity.

Calvin reflected positively on this experience due to the interactive nature of his teacher and the engaging introduction to that day's lesson. In contrast, Reed identified a slightly different experience with teacher modelling where the teacher brought in a prop and described it to the class. He recalled that his teacher:

> Brought in this, its name is Mr. Choppy and it's like a body and it's half human and half with the like parts that can pull out. He showed us, like, this is the liver and the lungs and that, and just talked about it.

Glenda added that: “I really enjoyed it when my mom came in with the stuff she works with and hamsters and talked about biodiversity and stuff.” Addison also mentioned increased interest when guests came in to speak or show something to the class.

Of the six students interviewed, only Reed explicitly expressed his interest in the teacher modelling approach saying: “I like when the teacher does it because then the teacher will show you what, how to do it, and what to do.” While Reed spoke positively about teacher modelling, he also alluded to the fact that it was particularly helpful only if he got to participate later in the lesson. This contention was more direct in statements made by Will and Macey. Will said: “Sometimes it is good. I like it a little bit, but ... umh ... but it is a little more fun if I, we, the class does it.” Macey added: “It's a good way because you can see better how stuff looks in real life. I would like more to do it with them [the teachers].”

Calvin was the only student to indicate how teacher modelling might be made more effective within his recommendations. Calvin emphasized that science lessons shouldn't just be delivered in lecture format. He suggested “that they should bring out, show them it and then do something about it. They should not just bring it out and just talk about it. ... I don't think that is the best way.” Will also touched on the “do something about it” idea when he spoke about why he enjoyed the way “Bill Nye the Science Guy” communicated science. In doing so, he referenced the importance of an engaging and entertaining instructor to better foster interest in the topic or activity being learned. “He is funny when he does it, so he doesn't just say this is this and make it really like a boring speech and he makes it really fun and he does something with it.”

Passive Learning Tasks

Second only to Active Learning Tasks, Passive Learning Tasks became a central topic within most interviews. Both in an impromptu manner and when asked directly, students highlighted a number of facets of this situational factor including past experiences where they were exposed to passive learning tasks, the rationale for their opinion of its use in the science classroom, and further recommendations for the use of these types of activities.

Discussion about passive learning tasks was largely generated when students were asked if they could think about science lessons that were the least interesting. When asked to give an example of such a lesson, Glenda responded:

> Probably one that was all like reading out of the textbook and answering questions that are kind of repetitive when reading out of the textbook. But I can’t remember an exact lesson. I really don’t like the ones where you just kind of read out of the textbook and answer the same questions and learn out of the textbook and stuff.

Calvin also supported this distaste in researching and summarizing information. He said quite forcefully:

> I hate when we have to read this big long booklet, say it was all these papers stapled together, and then we have to highlight what is really important and then have this huge huge paper like this long, both sides and a question here and two lines, and question two lines, with questions on this side and on this side that we had to answer.

Reed also mentioned several experiences with passive learning tasks as uninteresting. When asked what it was he disliked about this approach he reported: “Not always, taking it off the board, I just don't really like taking notes off the board. Filling in the blanks are a bit better. I'd rather do experiments.”

Further emphasizing their dislike of the use of passive learning tasks, three students listed specific reasons. Will had trouble with written expression, mentioning:

> I really don't like writing down things because one thing when I start writing the question and we need to write the answer I always get stuck on. ... I can't really write it because the ideas are in my head and I just can't find a way to get them onto the paper. And that always stops me.

Glenda needed more than just passive approaches to effectively visualize scientific concepts. “Umh, it doesn’t help me see things. I really like visualizing things a lot so it’s why I really like hands-on stuff instead of the stuff that is just written in a textbook. I like to visualize things.” Calvin disliked the time-consuming nature of writing activities.

When asked about a writing task in which he had participated, he said: “I don't like that because it just takes time and I like getting things done quickly.”

In contrast to the negative opinions towards passive learning tasks mentioned by all interview participants with the exception of Reed, several positive points came out of these discussions as well. Two students shared constructive reasons for their use. According to Reed, “when they give out notebooks, that is really good because if you have something that the teacher didn't show you how to do, you can just look it up.” He also thought that it was “important for studying when you have a test, the notes that she [teacher] wrote down.” As an extension to his previous comment about having difficulty with writing tasks, Will added that, in some cases, writing can be helpful. He suggested that “We still need to write down stuff because if we don't write down it's stopping our writing skills ... a little bit ... and if we write it down it's sometimes a little easier to picture it.”

With respect to recommendations made concerning passive learning tasks, students generally listed preferential types of activities that might replace or complement passive learning tasks. Macey, however, was more specific when reflecting on some of her past science lessons. “I wouldn't give them a sheet and expect them to know how everything is supposed to work.” This statement largely supported the general disinterest in synthesizing written information and simply re-writing it. Thus, while the majority of the comments about passive learning tasks were negative, each student had an experience to share, and older students distinguished themselves with the recognition of the positive points as well. Glenda blended these thoughts well by commenting: “I do like learning as much as I can about science in any way we’ve got, so I do like reading and writing but I like when the teachers do a lot more.”

Joy of Discovery

As the students began describing past science experiences that they enjoyed, the innate joy of learning was often apparent in their tone and in their message. This theme of joy of discovery came through in nearly all conversations, most commonly with respect to a pleasant experience in science.

When speaking about what makes science interesting to him, Reed said: “The stuff that you learn about science, like, the stuff you didn't know, that just makes it really interesting.” Glenda concurred, stating “that I really love learning about stuff in science that are really amazing to me so I really enjoy that.” After reflecting on a particular science lesson, Will mentioned: “I thought that was really interesting because I didn't even know that was possible.” About a separate lesson from a unit on sound, he “thought that was really interesting because I've seen tuning forks but I had never actually knew a tuning fork sounded enough to actually make something jump.” Calvin also mentioned similar discoveries, while venturing an explanation about the purpose of science as well: “Well magnets are really like neat .... because I don't understand them and I want to understand them and that pretty much is what you need science for, understanding things.”

The source of this fascination in the unknown appeared to not only be generated by the presentation of the lesson, but seemed largely connected with the nature of the content itself. While many topics in science might be more interesting than others, it seemed to be those topics that connected with students' realities and a deeper understanding of items already familiar to students that were the most engaging.

Summary

In the interviews, the four situational factors were discussed, some briefly and others in greater detail. The two factors most discussed were active and passive learning tasks. These factors seemed to have the most impact on these students. The majority of the participants had strong opinions about these factors' use in the science classroom. However, it was not apparent whether these opinions were caused by a lack of, or an overabundance of, exposure to a given factor. During the analysis of student comments, the use of these two approaches in the classroom almost appeared dichotomous. Students often discussed the two in tandem, explaining that active learning tasks should replace, or at least be used more frequently than, passive learning tasks. Calvin outlined this idea when he stated: "I'd rather be building the structure than writing about the structure." The remaining two situational factors, social interaction and teacher modelling, were also discussed by all students, although these factors seemed to yield less importance to the students when compared to active and passive learning tasks. This lesser importance was indicated by the amount students had to say about these factors, as well as the nature of their comments.

Preferences for certain situational factors emerged across the qualitative findings. From preferred to least preferred, interview participants ranked active learning tasks, social interaction, teacher modelling, and finally passive learning tasks, as the general order with which they would identify their level of interest in the situational factors. However, regardless of these preferences, a satellite theme emerged titled "Joy of Discovery," which outlined student comments that reflected their general fascination with scientific phenomena and the learning of these phenomena. This emerging theme, along with the four others deduced from the situational factors examined in the survey, served as informative sources with various parallels to the quantitative findings. These parallels will come much to the satisfaction of Calvin who asked once his interview was complete: "How is this interview going to help with the questionnaire stuff?"

CHAPTER 5: DISCUSSION

The purpose of this study was to understand interest in the elementary science classroom as affected by different teaching methods. To achieve this goal, this study sought to answer four central research questions:

Question #1: To what extent do grade and gender relate to situational interest, factor frequency, and individual interest?

Question #2: To what extent do factor frequency and situational interest factors relate to each other?

Question #3: To what extent do different situational interest factors and factor frequency relate to student interest in science, as moderated by grade level (4-6) and gender?

Question #4: What makes for interesting and effective teaching of science in the eyes of the students?

In the first section of this chapter, results are further elaborated and interpreted. The findings are then related to significant research in the fields of interest and science education, where parallels and distinctions are identified and discussed. Each research question is discussed sequentially. In the second section, study limitations are addressed, and implications for future research are outlined. The third section concludes with recommendations emerging from this research and reflections on the study.

Examining the Research Questions

Research Question #1: To what extent do grade and gender relate to situational interest, factor frequency, and individual interest?

The intention of this research question was to gain a clearer understanding of learning preferences and any perceived differences in the frequency of exposure to specific instructional approaches across gender and grade levels. Of the studies examining interest in elementary level science, the majority of studies identified gender differences. These differences were associated with an increased positive bias toward science for boys as compared to girls. In an often-cited study, Greenfield (1997) noted that these gender differences tend to emerge in the later elementary grades. This conclusion is further supported by the work of Jarvis and Pell (2002) for students aged 6-11, and by Jones et al. (2000) and Stark and Gray (1999), which examined students from the sixth grade. However, these findings are not universal. A study by Murphy and Beggs (2003) revealed that primary level girls were more positive than boys with respect to their enjoyment of science. Additionally, in an examination of transitioning Grade 6 students, Logan and Skamp (2008) found no significant gender difference in science interest scores.

Results from the present study do not reveal significant differences between genders for interest in science, and are therefore not comparable to the majority of findings outlined in the existing literature. The lack of significant findings may be the result of several key items identified in the science interest literature as well as methodological limitations within this study. As outlined by Greenfield (1997), significant gender differences do not appear until the intermediate grades; therefore, it may be possible that students in Grades 4, 5, and 6 are too young to manifest any significant gender differences. Furthermore, from a methodological standpoint, the overall sample was composed of 178 students, thereby limiting statistical power. As well, three statements used within the questionnaire section measuring individual interest in science were later removed as a result of factor analysis when constructing this scale. Two of the removed statements: "I enjoy reading science books or articles," and "I like watching science shows on TV" may have also contributed to the lack of significant findings. As noted in Greenfield (1997), statements representing passive activities such as these, which are often included in measures of attitudes toward science, are generally favoured by girls.

Of the studies investigating the state of student attitudes toward science, all those reviewed discussed the decline in positive attitudes toward and interest in science as grade level increased. However, the results obtained in this study do not suggest any significant differences in science interest from Grades 4 to 6. These results are in direct contrast to those of Jarvis and Pell (2002) who outline a considerable decline in science enthusiasm for students aged 6-11. Supporting the Jarvis and Pell findings is the work of Murphy and Beggs (2003) who observed a marked decline in the enjoyment of school science between Grades 3-6. These two studies were the only ones located that specifically examined science interest across elementary grades. All other relevant studies found were limited to the intermediate and secondary levels, often assuming that the decline in science interest develops throughout these grade levels. This assumption made it particularly difficult to draw comparisons to the present study.

One potential explanation for the differences observed among the findings highlighted in Jarvis and Pell (2002), Murphy and Beggs (2003), and this study is the construction of the scale measuring science interest. In Jarvis and Pell, the authors used the term science enthusiasm and measured this construct through the use of responses to specific statements such as “I should like to be a scientist,” and “One day, I should like to go to the Moon.” These statements are forward looking and not clearly connected with existing student experiences in science. They therefore are likely to measure a disposition quite different from the interest scale in this study, which was constructed with statements such as “Science is fun” and “Science is boring” (reversed). The statements comprising the interest scale for Murphy and Beggs (2003) more closely resembled those used in this study, although student responses were limited to a three-point as opposed to a five-point scale.

After investigating how students across grade levels and of different genders associate interest with each situational factor, the only significant finding was that girls displayed greater interest in passive learning tasks in science than boys. This result matches a study by Stark and Gray (1999) that outlines attitudes to different types of learning activities as moderated by gender. In parallel with the findings from this study, Stark and Gray found that boys harboured stronger negative attitudes toward such activities as writing about science, filling out science worksheets, and reading about science. Each of these items represents similar variables to those used in constructing the Passive Learning Tasks scale in this study. Stark and Gray also noted that girls tended to offer more neutral responses and were more tolerant of passive type activities than boys were. Greenfield (1997) suggests that this gender difference is representative of a larger phenomenon that is primarily caused by gender-biased classrooms, where teachers commonly devote more time to boys with respect to their efforts and behaviour.

When examining associations among the four factor frequency subscales, gender and grade analyses suggested that Grade 4 students were exposed to teacher modelling more than either Grade 5 or Grade 6 students, with Grade 5 students receiving the least exposure of the three grades. No significant relationships were found for gender. These data are somewhat comparable to frequency findings outlined in Stark and Gray (1999). These researchers reported a shift in teacher modelling related experiences among students between the end of elementary and the beginning of secondary school. The authors largely attribute the consistency of this trend to the secondary school transition. Unfortunately, with respect to understanding the present findings, their data do not distinguish among grades at the elementary level.

Research Question #2: To what extent do factor frequency and situational interest factors relate to each other?

In the pursuit of understanding the effectiveness of different teaching approaches in elementary science education, the purpose of this question was to ascertain whether a greater exposure to a particular approach would lead to a greater interest in that approach. Further, it was relevant to find out the nature of the frequency/interest relationships for each of the four situational factors. Of the four, interest in teacher modelling and social interaction increased with greater exposure to the congruent situational factor.

No studies found in the literature discussed whether or not increased exposure to a particular instructional approach would lead to an increase in interest in that approach at the elementary level. However, one study by Ornstein (2006) examined the relation between the frequency of hands-on experimentation and student attitudes toward science at the intermediate and secondary levels. In part of his study, Ornstein examined the frequency of hands-on activities as reported by the students and their relation to various attitudinal factors. His findings revealed that student "interest in science classes and activities," "confidence in science abilities," and "interest in science outside of school" all decreased as the frequency of hands-on activities decreased.

Contrastingly, no relationship was found between frequency and interest for active learning tasks in the present study. This unanticipated result was against expectations, as both Ornstein (2006) and Osborne et al. (2003) indicate that hands-on and active types of teaching strategies trigger the greatest amount of interest. Additionally, no relationship was found between frequency and interest for passive learning tasks. This finding was also surprising as previous studies often cite strategies associated with this factor as related to a decline in interest (Logan & Skamp, 2008; Osborne et al., 2003; Singh et al., 2002).

While correlations across frequency and interest factors are minimal, stronger connections were found among frequency factors and among interest factors. The strongest correlations were observed among interest factors between interest in teacher modelling and passive learning tasks, and also between interest in social interaction and active learning tasks. These associations are not surprising as social activities are often related to active tasks, and teacher modelling is often seen as a passive activity with less student participation.

As a possible explanation for the lack of significant relationships between frequency and interest factors, two opposing processes may be at work. One process, identified by the model for interest development, supports the idea that the more a person is exposed to a particular situational factor, the more interested that person would be in that factor (Pattern A). Hidi and Renninger (2006) propose in their four-phase model of interest development that to maintain a triggered situational interest one must also maintain continued exposure to the factors responsible for the triggered connection between person and content. The opposing process supports an inverse relationship between frequency and interest. In this situation, the more a person is exposed to a particular situational factor the less interested that person becomes in that factor (Pattern B). This possibility is based on the conception of novelty as represented in the work of Mitchell (1993) and Bergin (1999). They propose that students are best engaged in classroom material when being exposed to new and challenging approaches.

The findings in this study do not seem to distinctively adhere to either of the processes mentioned; they may therefore be a balance of both. Some respondents may best identify with pattern A, while others align more with pattern B. The cumulative result of the combined responses balances the effects of each pattern and therefore results in the lack of strong correlations or trends associated with this analysis.

Research Question #3: To what extent do different situational interest factors and factor frequency relate to student interest in science, as moderated by grade level (4-6) and gender?

To better understand how different frequency and interest factors relate to individual interest in science, an examination of which group of predictors, either frequency or interest, best predicted general interest in science was conducted. The results revealed that frequency factors had little impact as a group and that no frequency factor was significantly related to individual interest in science. However, the interest group was observed to be a significant predictor of the individual interest scale with both active learning and passive learning tasks as statistically significant factors.

The insignificant frequency results were largely unexpected. It was initially thought that students who have experienced various instructional approaches at a greater frequency would enjoy science to a greater extent than those students with minimal exposure to varied approaches. This contention is supported by the findings of Ornstein (2006) for active learning tasks. He found that students claiming to have experienced a greater number of hands-on science activities in class held more positive attitudes toward science. While not specifically focussing on interest or attitudinal influences, House (2006) similarly reported that the more frequently students were exposed to situational factors, such as social interaction and active learning tasks, the greater the student achievement on science test scores.

A possible explanation for the lack of significant associations between the frequency factors and individual interest in science may be the low reliability of the scales constructed for each frequency factor. The scale construction for the frequency factors replicated the construction of the scales for situational interest. This format was chosen to more accurately examine the correlations between the frequency and interest factor scales. As Cronbach's alpha values for the frequency factor scales ranged between .35 and .63, the internal consistencies of the frequency factor scales were relatively low, potentially contributing to ill-defined frequency scales and the lack of significant correlations with the scale for individual interest in science.

Even though the low scale reliabilities may help explain the lack of any significant relationships between exposure to certain instructional approaches and students' individual interest in science, the results of this study still point to a pedagogical relationship that is more complicated than previously hypothesised. Perhaps the frequency and type of activities done in class are not as influential as initially thought, and extra-curricular activities and experiences play a key role in predicting a student's general interest in science. Supporting this contention, as part of her discussion about gender difference in attitude toward science and cultural socialization, Greenfield (1997) outlines that students, often boys, with greater exposure to explorational toys and games during extra-curricular play develop a stronger experiential background to draw upon in the classroom when solving science-related problems. This view is also supported by research examining the influence of extra-curricular visits to science-related exhibits and events. Jarvis and Pell (2002) document a sustained increase in science interest and enthusiasm and more positive views of the value of science in society after visits to a science museum.

The significant interest results in the present study were expected and paralleled the findings in several other studies. While no quantitatively based studies highlighted the relationship between interest in specific situational factors and general interest in science, this relationship was outlined in several qualitative pieces. In qualitative studies such as Piburn and Baker (1993), Logan and Skamp (2008), and Osborne and Simon (1996), students who highlighted specific interests in activities such as experiments and group work also discussed a greater interest in the subject of science and its importance in everyday life. These studies do not, however, discuss a connection between interest in passive activities and an increased interest in the subject of science as revealed by the quantitative results in the present study.

As an extension to identifying which group of predictors, either frequency or interest, best correlated with students' general interest in science, further analyses were undertaken to determine the strongest predictors of individual interest in science for each gender and grade. The best predictor overall for gender and grade level was interest in passive learning tasks. This finding is in direct contrast to the hypothesised results. It was expected that the best predictor of individual interest in science would be the factor with the greatest amount of student interest (Active Learning Tasks). It was additionally hypothesized that the factor with the least amount of student interest (Passive Learning Tasks) might prove to be the worst predictor or even an inverse predictor of individual interest in science. The positive correlation between general interest in science and interest in passive learning tasks diverges from the majority of the literature in that the situational factors most commonly associated with positive attitudes toward science at all grade levels are those related to active learning tasks and social interaction (Osborne et al., 2003). Specifically in the elementary grades, leading factors have been identified as experimentation, hands-on tasks, using a computer in science, small group work, and team investigations (Jarvis & Pell, 2002; Murphy & Beggs, 2003).

While the significance of passive learning tasks as a predictor for individual interest in science runs counter to the literature, these findings can be interpreted as logical for students who come to class with an existing and resolute interest in science. For these students, interest in science is unwavering no matter the instructional approach used in the teaching of the content. However, for students who do not initially harbour strong interests in the subject of science, the methods used in teaching the content are a much stronger influence on their interest in the subject. This interpretation is also represented within the comments from the student interview component of this study. Glenda, a Grade 6 student, characterised her learning experiences by saying "I do like learning as much as I can about science in any way we've got, so I do like reading and writing but I like when the teachers do a lot more." Moreover, the significance of passive learning tasks is found to a certain extent across both genders and all three grade levels. The comprehensive nature of the passive learning factor would also appear to be reasonable considering that students with existing interests in science would not necessarily be of a single grade or gender; they could well be spread relatively equally across all groups.

The examination of the mean scores for each of the statements used in the construction of the passive learning tasks scale reveals that they are the lowest of all the interest statements within the questionnaire. Additionally, the standard deviation values for the passive learning task statements are among the highest, indicating that these statements have a greater range of responses along the 5-point interest scale. These figures lend themselves well to the idea that students with an existing interest in science may tend to score higher on these statements as a result of the subject being studied, and that those with less of an initial interest in the topics being covered score the lowest as they are more intensely affected by the instructional approach being utilized. The latter group of students would then fall into the more common findings highlighted in the literature wherein students are least interested and engaged in passive learning tasks.

Other findings emerging from this analysis highlighted active learning tasks and social interaction as the next best predictors of individual interest in science following passive learning tasks. This finding remains consistent with current literature as discussed in a recent review by Osborne et al. (2003). Two additional items of note were that the primary predictor for girls was passive learning tasks, accounting for 34% of the variance, whereas this same factor only accounted for 7% of the variance for boys. This result was not surprising considering the gender differences observed in the analyses for the first research question as well as the situational factor preferences by gender reported in Stark and Gray (1999). The second item of note was that the best predictor of individual interest across grades incrementally changed. While passive learning tasks, accounting for 43% of the variance, was the strongest predictor for Grade 4, this factor diminished to account for 29% of the variance for Grade 5, and by Grade 6 was no longer the strongest predictor. This finding was consistent with the work of Jarvis and Pell (2002) who outline that student interest in tasks such as writing and reading diminishes considerably through the elementary grades.

While certain results support trends in instructional preferences across gender and grade level as highlighted in current literature, the significance of passive learning tasks as a predictor of individual interest in science was somewhat surprising. Perhaps even more surprising was the relatively low influence of active learning tasks on students' general interest in science. These findings contrasted the results highlighted in the research reviewed. Ultimately, the findings within this section of the present study make it quite difficult to infer what instructional approaches teachers should be using in the classroom if they want to better engage their students and foster a greater interest in science-related content.

Research Question #4: What makes for interesting and effective teaching of science in the eyes of the students?

In this section, the research question is addressed by first examining student views on interesting and effective teaching practices, then by outlining student views on uninteresting and ineffective teaching, followed by the impact of gender and grade level on participant responses. As indicated in the comparison of means in the quantitative component of this study, students reported that they were most interested in active learning tasks, followed by social interaction, teacher modelling, and lastly passive learning tasks. These results held across both genders and for all grade levels. To further complement the quantitative data utilized in this study, qualitative interviews were conducted to measure the nature of interest in the science classroom as seen through the eyes of the students. In a general sense, the discussions with each of the six interviewees also reflected this trend in factor popularity.

Student views on interesting and effective teaching. As presented in Figure 1, the situational factors influencing student interest as adapted from Bergin (1999) are in many ways congruent to the dimensions representing effective and engaging teaching that emerged from the participant interviews. This first sub-section highlights each of these dimensions that are largely consistent with the themes presented in the results section. The dimensions described are: active learning tasks, social interaction, novelty and challenge (joy of discovery), relevance and meaning, and choice.

Active learning tasks emerged as the overarching theme within the student responses and emphasized the use of experimentation and the manipulation or creation of objects. Students universally stated that the use of activities where they were "doing" and using their hands was their preferred way to learn and experience classroom science. All students further qualified their experiences with this type of instructional approach in a positive way indicating that hands-on activities in science were the most interesting as these activities allowed them to have fun and enjoy the subject. For instance, Calvin spoke to his preferred approach to learning science by saying that "Science class is interesting with projects. If you are doing an experiment/project or something that was brought out in an interesting way to you, that you get excited about it." Similarly, as a result of their interviews, Murphy and Beggs (2003) hypothesized that it was perhaps the lack of experimental work that was disengaging students and turning them away from science. Several students in the present study remarked that they enjoyed active learning tasks best as these tasks "kept their interest" and made science something to look forward to. The active and experiential experiences discussed by all six interview participants in this study also resonate with research by Mitchell (1993) where he found that the variable corresponding best with situational interest was active involvement.

The benefits of social interaction also arose from the student interviews and aligned well with yet another situational factor directly examined in the study's survey. The elementary level students interviewed in this study emphasized that cooperative activities made working in science easier and more interesting. A majority of students specified that group work was particularly helpful as group colleagues often served as resources when one member got stuck, and that cooperative activities assisted with the generation of ideas and different perspectives. Will, a Grade 4 student, summarized this advantage by stating that “It is a lot of fun working as a team because you can actually share your ideas with other people ... If I can share my ideas and they can share their ideas with me it kind of is easier to work together and find out what the actual ... the answer.” Along the same lines, Calvin, in Grade 5, explained the advantages by commenting that “it's better because then it gives you more confidence and you have a bigger brain, like two brains are better than one unless they don't work together.” From a practical standpoint, Glenda, a Grade 6 student, emphasized that partner exercises were very important in her classroom and that strategically pairing students with a sustained interest in science with those less interested in the topic often helped to engage the less engaged students in the subject at hand.

The dimension of novelty and challenge emerged from the student voices as another key motivational variable. Students interviewed in this study often mentioned that discovering new things, and seeing or doing something they had never done before, were among the experiences in science that they enjoyed most. Components of this theme resounded so much in the transcripts that it was coined the “Joy of Discovery” within the results section and highlighted the fascination and amazement students spoke of when learning about something they did not know or something that was counter to their existing understanding of a particular phenomenon. Reed summarized his thoughts on the matter by saying that "The stuff that you learn about science, like, the stuff you didn't know, that just makes it really interesting." Additionally, it seemed as though the students were engaged by the challenges inherent in discovering the new concepts and scientific work they were undertaking. This majority view among interviewees did not, however, appear to be consistent with qualitative research by Logan and Skamp (2005, 2008) where students who found science challenging also found the activities and topics less interesting as a whole.

Identified as relevance and meaning, this dimension was one of two that cut across all major themes presented in the results section. The dimension emerged by interviewees reporting more enjoyment in science class and stating that they understood the material better when it was about something to which they could relate. Focussing on topics that connected with students' realities and a deeper understanding or new twist to items already familiar to students was highlighted as a positive influence on student interest. Will also pointed out that, by working with something "directly" in science class, it made the concept being learned much more meaningful. Osborne et al. (2003) and Simon (2000) indicate that relevance and meaning are important variables influencing student attitudes toward science. They continue by adding that a focus on these variables is important to aid in fostering a stronger value for science in society and a more positive view of scientific innovations in everyday life. While this latter idea emerged briefly in a statement by Calvin about the purpose of science, no other interviewees touched on this concept specifically.

The third aspect to cross-cut the major themes was that of choice. Students suggested that, when offered a choice in the activities they were to undertake or the topics they were to work on, they could better avoid activities or topics of lesser personal interest to them. Calvin added that, as a teacher, he would offer a choice of activities but also ask students, “What do you want to learn? What are you interested in?” and would design parts of his lessons based on the responses of his students. The topic of choice emerged somewhat indirectly among the students interviewed and, as discussed by Deci, Vallerand, Pelletier, and Ryan (1991), seemed to contribute to a sense of self-determination by satisfying each student's need for autonomy.

Overall, the dimensions revealed by the student discussions support research by Bergin (1999), Jarvis and Pell (2002), Murphy and Beggs (2003), Piburn and Baker (1993), and Stark and Gray (1999) indicating that hands-on and cooperative activities in science were the most interesting among elementary level students and that these activities encouraged students to have fun and enjoy the subject. Further, Zahorik (1996) reported that both elementary and secondary level teachers enrolled in education-related graduate courses outlined the development of interest as a main component in their teaching and that the use of hands-on, cooperative, and meaningful activities was the best way to generate student interest.

Student views on uninteresting and ineffective teaching. Three dimensions emerged with respect to uninteresting and ineffective teaching from the student interviews: writing and copying, busywork and repetition, and lecturing. The first two dimensions derive directly from the passive learning task theme as outlined in the results section. One task leading to unanimous disinterest was the synthesis of written information, particularly through copying. It was largely suggested that reading sections of a textbook or worksheet and answering related questions was “boring” and not helping the students learn. Reed and Glenda also mentioned that they lost interest when required to “copy from the board” and “fill in the blanks” and highlighted that this copying/filling in was the part of their science lessons that they liked the least. Will added that to him the writing activities were the most difficult and frustrating. Although the negative view of writing activities appears across the literature reviewed, Logan and Skamp (2008) comment that this distaste for writing is most commonly associated with the purpose of the task and not necessarily with the act of writing itself. For instance, if students were writing about the findings of a recent experiment or a narrative as a method of communicating scientific ideas, Logan and Skamp suggest that students would likely maintain their interest in the task at hand.

The second dimension largely apparent in passive learning tasks is that of busywork and repetition. Participants in this study tended to be quite effective at detecting busywork to fill class time. These students identified a strong disinterest in science activities that were not practical stating that these “were not fun” and did not help them learn. Related to the busywork that was sometimes given to them in science, interviewees also identified the constant revision of topics and the repetitive nature of some activities as factors leading to their disinterest in the subject. Macey, a Grade 5 student, expressed this dimension in her comments about enjoying science lessons less “when you've already done stuff and they want to make sure you know it and they just keep going over it and it's just not as fun.” This finding supported data reported by Murphy and Beggs (2003) where students spoke about their disinterest in national test preparation as they strongly disliked the repetitive nature of the practice activities and topic revisions.

Lecturing, namely teachers who spoke at length about science topics and read out of the textbooks, also led to disinterest. The majority of students emphasized that lecturing and “boring speeches” were simply disengaging instructional practices. These students also added that they preferred doing what the teacher was describing along with or after their description, rather than just having a concept or item described or shown to them. As Will commented,

> To me it makes you learn a little bit more because when you're watching the teacher all the time ... you don't really get it. You can see it but you're kind of thinking that ... well if I was doing this what different things could I do to make it work and it ... always makes me feel better if I can do it so I can actually experiment a little bit more.

Overall, student views about each of the emerging dimensions remained largely consistent with science interest research, which largely outlines the negative student attitudes toward passive learning tasks in school science across both the elementary and secondary levels (Greenfield, 1997; Harlen, 1997; Jarvis & Pell, 2002; Logan & Skamp, 2008; Murphy & Beggs, 2003; Myers & Fouts, 1992; Osborne et al., 2003; Piburn & Baker, 1993; Simon, 2000; Simpson & Oliver, 1990; Singh et al., 2002). Students in the present study also made a point of emphasizing that any assigned activity, whether active or passive, is made more interesting when it serves a clear purpose and is relevant.

The impact of gender and grade level. While many studies examining student attitudes toward school science through the use of attitudinal scales and other quantitative methodologies found significant gender differences, the student interview component in this study did not reveal any clear disparities by gender. However, in their qualitative study, Logan and Skamp (2008) also did not identify any major gender differences between their female and male respondents; only minor differences appeared in the preference of science content. Even though both genders in the present study shared, to a great extent, the same views about what activities were best or worst at fostering their interest in science, they tended to discuss their perspectives in different ways. Overall, boys were more prone to discussing their science experiences in detail, qualifying each component of their experience as they went along. In comparison, the girls more commonly qualified the tone of their experience and briefly summarized the major components. A possible explanation for this disparity may be related to the gender of the researcher and that only one interview took place with each student, the researcher and student not having individually met prior to the interview. Both gender and the lack of familiarity with the researcher may have caused discomfort for some interview participants, particularly those of the opposite gender.

As with gender, no major grade level differences were noticed in the student discussions. However, while all interview participants mentioned disinterest in passive learning tasks, the older students appeared to associate a greater amount of negativity to these tasks than the more ambivalent Grade 4 students. This point aligns well with results from the quantitative section of this study, which revealed that students became less interested in passive learning tasks as the grades increased. Additionally, the respondents in Grade 6 showed a greater ability to weigh both the advantages and disadvantages of the factors they critiqued. This ability to balance views was most likely related to their age and the greater complexity of their responses.

The qualitative results obtained from the student interviews provided important insights into the views of elementary science students and supported the overall findings by other qualitative studies of the same demographic. Students seemed genuinely interested in participating and also seemed to appreciate the emphasis on the value of their personal perspectives. Furthermore, similar to points made by Piburn and Baker (1993), students appeared to welcome the opportunity to share their thoughts about how they were taught as the occasion did not surface very frequently for them.

Limitations of the Study and Implications for Future Research

The limitations emerging from this study fall under three general areas, which relate to the study instruments, population, and procedure. The first limitation is related to the study instruments and was associated with the construction and trial of the questionnaire. While some of the 54 self-report items of the questionnaire were adapted from existing surveys used by researchers in science education, namely Jarvis and Pell (2002) and Murphy et al. (2006), the majority of questionnaire items were created to suit the purposes of this study. Data collection began as soon as possible after ethical clearance was received, leaving no time for piloting. Although factor analysis and reliability estimates were used to analyze the scales embedded in the questionnaire and items were subsequently dropped, piloting the questionnaire before the collection of data would have allowed for the revision of key items to ensure the valid measurement of the dispositions associated with each scale and to allow for the modification of certain questionnaire items to improve clarity. Additionally, the mirrored scale construction of situational frequency based on the situational interest scales did not prove as effective as initially expected. The reliabilities of the frequency scales were poor, which may have led to the lack of significant correlations with any other scale, gender, or grade level. It may also be advantageous to reconsider how the situational frequency data are collected. The perceived nature of student responses for situational frequency led to varying levels of perceived exposure to certain tasks, even among students of the same class. In future, it may be more effective to collect these data through more objective means, perhaps via classroom observations or the classroom teacher.

The second area of limitation related to the study population. For the sake of convenience, data collected in this study were limited to six schools in one school board.

While the schools were situated in a mixture of urban and rural settings, the qualities that constitute these schools may be unique to this area. Therefore, with such a limited population, it is difficult to generalize the data to other parts of the province or country. In future, it is advised that the study population not be limited geographically for either or both the administration of a questionnaire and/or the collection of data by way of interview.

The third set of limitations is associated with the study's procedures. As a result of the timeframes dictated by the ethical clearance processes and the timeline of suggested progression in the M.Ed. program, the majority of the questionnaires were administered in the late fall. This particular time within the school calendar inherently caused three problems. First, the month of November is generally a busy time for elementary school teachers as they are in the midst of preparing the first set of student report cards. In anticipation of this upcoming process, it was difficult to recruit teachers to participate in the study. Second, as a result of it being relatively early in the school year, some teachers had not begun teaching their science units. Consequently, those students completing the questionnaires from these classrooms were not able to accurately refer to any of the science lessons taught by their teacher. To aid in circumventing this problem, students were ask to think of science lessons from either the current or the past year when filling out the questionnaire. This attempted accommodation ultimately led to the third concern, namely, that students were having difficulty remembering their last science experiences and were confusing the grades during which they experienced certain science activities. To avoid these concerns, it would be advisable to collect questionnaire data of this sort during April and May to afford teachers a little more time to accommodate the collection of the data, and allow students to more frequently and comprehensively experience the subject or dispositions measured by the questionnaire.

Another limitation under the umbrella of study procedures was the sampling of interview participants. As part of the parental consent form for the survey, parents or guardians were given the opportunity to express interest in allowing their children to be interviewed. This procedure limited the eligible population in two ways. First, the ability of the student to independently choose to participate was compromised by the process of having to get the consent of the parent/guardian and get the form signed, which ultimately limited the number of interested respondents. Second, by making the process voluntary, those students who did express interest in being interviewed were more likely to have a more positive view about the subject, and were also more likely to be extraverted. As a result of the ethical limitations with respect to the age of the students, both of these processes were necessary and could not be easily modified. However, it may be easier in the future to combine the survey and interview consent forms into one so that the consent procedure would not have to be repeated. This modification would also save a great deal of correspondence and time.

The final limitation in reference to the interview process is related to the space where the interviews took place as well as characteristics of the person who conducted the interviews. Most interviews were conducted in a quiet space within the school, although often the space was next to offices, the resource room, or the staff lounge where other teachers were either present or circulating. The open location of the interviews, in addition to the periodic presence of members of the teaching staff, may have inhibited students from engaging in-depth in discussions about instructional approaches they have experienced, enjoyed, and preferred. Also contributing to the potential for discomfort might have been the age and gender of the interviewer. Having only encountered the researcher/interviewer when the questionnaire was administered, this was the first occasion when the student being interviewed and the researcher/interviewer had personally interacted. Moreover, the interviewer was a 25-year-old male, which may have contributed to further discomfort, especially with the female interview participants. Due to the limited space and hectic nature of most elementary schools, it would likely be difficult to avoid any open spaces, disruptions, or noise during the interview process, although with better advanced preparation a specific space might be located that might help minimize the effects potentially leading to any discomfort. While it may also be difficult to avoid any discomfort as a result of the age and gender of the interviewer, it may be possible to establish a greater level of trust by meeting the student at a time before the interview takes place or engaging in an informal activity together shortly before conducting the interview.

Recommendations

The findings of this study continue to illustrate the importance of interest in the elementary science classroom and, to a certain extent, highlight instructional approaches that may be more effective in engaging students in the pursuit of learning and understanding of scientific topics. Three primary recommendations arise. First, science teachers should continue to emphasize open-ended and exploratory endeavours in the late elementary grades. Second, teachers should integrate a diverse assortment of instructional strategies in their science lessons using novel and relevant topics and activities. Third, science educators should use purposeful investigative activities and experimentation as part of their teaching.

Educators who continue focussing on open-ended and exploratory endeavours in the late elementary grades better maintain student interest in science as grade levels increase. This strategy may easily be adapted for these grade levels by resetting appropriate goals and expected outcomes all while instilling in students a greater level of accountability in the quality of their work. This recommendation largely stems from the findings indicating that passive learning tasks become less popular as grade level increases as supported by the need for more active learning tasks mentioned by Grade 6 students in the interview component of the study and by the trend in the quantitative data with respect to passive learning tasks.

In light of the qualitative findings, elementary teachers should integrate a diverse assortment of instructional strategies in their science lessons with particular emphasis on activities that involve the manipulation or creation of objects. In addition, interview participants identified the benefits of coupling active learning tasks with opportunities for students to interact socially when working on a task in either paired or small group settings. When designing lessons, science instructors should also consider incorporating novel and challenging components with the appropriate level of support to help attract and sustain student interest. In addition, instructors should focus on relevant topics or examples that connect with students' realities and are meaningful and important to them. Finally, teachers should allow students to have a certain level of control over their own learning by according them choice over topics, project ideas, and tasks to accomplish. As indicated by the richness of the qualitative data and the excitement of the students to share their perspectives and experiences, science educators should take the time to understand the individual interests of their students so that they may better connect and create meaning in the concepts being taught.

Lastly, teachers should lend a greater focus to experiment-related activities. While the current results do show that active learning tasks have a lesser impact on predicting student interest in science, the results equally do not show that student exposure to active learning tasks diminish student interest in science. Using the interpretation that passive learning tasks are only enjoyed by those students with an existing and unwavering individual interest in science due to their similar enthusiasm regardless of instructional approach, the high mean level of interest in active learning tasks and the recommendations by interview participants point toward the use of active learning tasks as effective for some but not all students. In light of this inference and the extensive literature supporting the use of hands-on activities, educators using purposeful investigative activities and experimentation in their science lessons will likely benefit the most students.

Based on the findings of this study, these recommendations, as supported in part by current literature in the field of science education, have been identified as the most effective ways of increasing student interest in science and have, in some cases, been associated with greater ease of learning and achievement (House, 2006; Osborne et al., 2003). It is recognized that the implementation of these recommendations will likely require a greater amount of preparation by teachers and class time devoted to science; however, it is believed that the benefits of these recommendations outweigh the costs.

Final Reflections

Ornstein (2006) highlights that, in scientific reasoning, conclusions do not indicate an end to an investigation; they are merely points along a continuum where a more refined clarity and understanding is being sought. In line with this reasoning, this study does little to define the state of interest in elementary science classrooms with any certainty; however, it is my hope that it contributes a little more clarity to research on pedagogical influences on student attitudes toward science and the practice of engaging young science students.

As a result of this research on student interest in science and my teaching and outreach experiences in the domain of science, I have come to believe that teaching quality and consequently the use of engaging instructional strategies are paramount to the success of science education. As they construct meaning, develop understanding, and expand their thinking processes, students should be permitted to "perform" science and should be granted the appropriate amount of time to thoroughly understand the ideas being studied. Rather than rush through or cut science short by giving in to more passive and didactic approaches to teaching science, elementary educators should allow their students to make full use of their innate sense of wonder and curiosity and experiment with the everyday complexities that surround them. By allowing students to explore through meaningful and relevant tasks and topics, teachers will not only foster interest and enjoyment in science; they will concurrently contribute to the establishment of a more scientifically literate citizenry.

This research has taught me a great deal about the complexities and the dynamic nature of interest, both inside the classroom and in general. It has also played an important role in developing my writing skills and has advanced my understanding of the research process. On a more personal level, the completion of this thesis has taught me a good deal about myself and that no matter how much you may forecast, plan, and work toward a certain outcome or a desired path, things change for better or for worse, and new paths must be forged.

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APPENDIX A: LETTER OF INFORMATION AND CONSENT FORM (TEACHERS)

Dear Teachers,

I am a Master of Education student in the Faculty of Education at Queen's University. I am writing to request the participation of your students in the research I am conducting. My research aims at outlining the role of interest in the elementary science classroom. I am particularly interested in examining what makes for effective and engaging teaching of science in the eyes of the students. The ultimate goal of my research is to highlight the state of student interest in elementary science classrooms and enhance student experiences in science through the improvement of existing instructional and curricular practices. This research has been cleared by the Queen's University General Research Ethics Board and the _________ District School Board.

To collect data for this research, I will be administering a five-part questionnaire, which should take approximately 20-30 minutes to complete. Questionnaires will be filled out anonymously during regularly scheduled class time, and once completed will be secured in a locked office. No names will be attached to the questionnaire. Additionally, with further consent from the parents/guardians I will randomly select one interested participant for each gender to participate in a 20 minute interview following the completion of the questionnaire.

I do not foresee any risks in the research participation of your students. Their participation is entirely voluntary. Any student is free to withdraw at any time. Your students are not obliged to answer any objectionable or uncomfortable questions.

This research may result in publications of various types, including my Master's thesis, journal articles, professional publications, newsletters, books and instructional materials. The identity of your students or the name of your school will not be attached to any form of the data that you provide and will not be known to anyone tabulating or analyzing the data, nor will these appear in any publication created as a result of this research. Upon request, you may receive the results of the study after its completion.

If at this point, or at any point in the future, should you have any questions about this research exercise, please feel free to contact me at (613) 531-0392 (e-mail: 1jg4@qlink.queensu.ca) or my supervisor, Dr. John Freeman at (613) 533-6000 ext. 77298 (e-mail: freemanj@educ.queensu.ca). For questions, concerns or complaints about the research ethics of this study, contact the Dean of the Faculty of Education, Dr. Rosa Bruno-Jofré at 613-533-6210 or the Chair of the Queen's University General Research Ethics Board, Dr. Stephen Leighton at (613) 533-6081 (e-mail: greb.chair@queensu.ca).

Sincerely,

Jovan F. Groen
M.Ed. Candidate
Faculty of Education
Queen's University

Jovan Groen
M. Ed. Candidate
Faculty of Education
Queen's University

Title: Interest in the Elementary Science Classroom

I have read and retained a copy of the letter of information concerning "Interest in the Elementary Science Classroom." My questions have been sufficiently answered. I am aware of the purposes and the procedures of the study. I understand that the participation of my students is voluntary, and that any student may choose not to complete the survey without consequence. I have also been informed of the steps that will be taken to ensure the confidentiality of all information.

I am aware that if I have any questions about this research exercise, I am free to contact Mr. Jovan Groen at (613) 531-0392 (e-mail: 1jg4@qlink.queensu.ca) or his supervisor, Dr. John Freeman at (613) 533-6000 ext. 77298 (e-mail: freemanj@educ.queensu.ca). I am also aware that for questions, concerns or complaints about the research ethics of this study, I can contact the Dean of the Faculty of Education, Dr. Rosa Bruno-Jofré at 613-533-6210 or the Chair of the Queen's University General Research Ethics Board, Dr. Stephen Leighton at (613) 533-6018 (e-mail: greb.chair@queensu.ca).

Teacher's
name:____

Teacher's
Signature:____

Date:____________________________________

Please write your e-mail or postal address at the bottom of this sheet if you wish to receive a copy of the results of this study.

APPENDIX B: LETTER OF INFORMATION AND CONSENT FORM FOR SURVEY (PARENTS/GUARDIANS)

Dear Parents/Guardians,

I am a Master of Education student in the Faculty of Education at Queen's University. I am writing to request the participation of your child in the research I am conducting. My research aims at outlining the role of interest in the elementary science classroom. I am particularly interested in examining what makes for effective and engaging teaching of science in the eyes of the students. The ultimate goal of my research is to highlight the state of student interest in elementary science classrooms and enhance student experiences in science through the improvement of existing instructional and curricular practices. This research has been cleared by the Queen's University General Research Ethics Board and the ________ District School Board.

To collect data for this research, I will be administering a five-part questionnaire, which should take approximately 20-30 minutes to complete. Questionnaires will be filled out anonymously during a regularly scheduled science class, and once completed will be secured in a locked office. No names will be attached to the questionnaire. Should you be interested in having your child further participate in this research in the form of an interview, please indicate your interest in the appropriate section on the attached consent form for further information.

I do not foresee any risks in the research participation of your child. His or her participation is entirely voluntary. Your child is free to withdraw at any time with no effect on his or her standing in school. Your child is not obliged to answer any objectionable or uncomfortable question.

This research may result in publications of various types, including my Master's thesis, journal articles, professional publications, newsletters, books and instructional materials. The identity of your child or the name of their school will not be attached to any form of the data that you provide and will not be known to anyone tabulating or analyzing the data, nor will these appear in any publication created as a result of this research. Upon request, you may receive the results of the study after its completion.

If at this point, or at any point in the future, should you have any questions about this research exercise, please feel free to contact me at (613) 531-0392 (e-mail: 1jg4@qlink.queensu.ca) or my supervisor, Dr. John Freeman at (613) 533-6000 ext. 77298 (e-mail: freemanj@educ.queensu.ca). For questions, concerns or complaints about the research ethics of this study, contact the Dean of the Faculty of Education, Dr. Rosa Bruno-Jofré at 613-533-6210 or the Chair of the Queen's University General Research Ethics Board, Dr. Stephen Leighton at (613) 533-6081 (e-mail: greb.chair@queensu.ca).

Sincerely,

Jovan F. Groen
M.Ed. Candidate
Faculty of Education
Queen's University

Jovan Groen
M. Ed. Candidate
Faculty of Education
Queen's University

Title: Interest in the Elementary Science Classroom

I have read and retained a copy of the letter of information concerning "Interest in the Elementary Science Classroom." My questions have been sufficiently answered. I am aware of the purposes and the procedures of the study. I understand that my child's participation is voluntary, and that she/he may choose not to complete the survey with no consequences to her/his standing in school. I have also been informed of the steps that will be taken to ensure the confidentiality of all information.

I am aware that if I have any questions about this research exercise, I am free to contact Mr. Jovan Groen at (613) 531-0392 (e-mail: 1jg4@qlink.queensu.ca) or his supervisor, Dr. John Freeman at (613) 533-6000 ext. 77298 (e-mail: freemanj@educ.queensu.ca). I am also aware that for questions, concerns or complaints about the research ethics of this study, I can contact the Dean of the Faculty of Education, Dr. Rosa Bruno-Jofré at 613-533-6210 or the Chair of the Queen's University General Research Ethics Board, Dr. Stephen Leighton at (613) 533-6018 (e-mail: greb.chair@queensu.ca).

Child's
name:____

Signature of
Parent/Guardian:____

Date:___________________________________

If you are interested in having your child further participate in this research in the form of an interview, please check the box below. If your child is selected to participate in an interview, a Letter of Information and consent form specific to the interview will be sent to you.

☐ Yes ☐ No

Please write your e-mail or postal address at the bottom of this sheet if you wish to receive a copy of the results of this study.

APPENDIX C: LETTER OF INFORMATION AND CONSENT FORM FOR INTERVIEW (PARENTS/GUARDIANS)

Dear Parents/Guardians,

I am a Master of Education student in the Faculty of Education at Queen's University. Thank you for expressing interest in the interview component of my research as signalled on the previous letter of consent concerning the questionnaire component. This component of my research also aims at outlining the role of interest in the elementary science classroom. I am particularly interested in examining what makes for effective and engaging teaching of science in the eyes of the students. The ultimate goal of my research is to highlight the state of student interest in elementary science classrooms and enhance student experiences in science through the improvement of existing instructional and curricular practices. This research has been cleared by the Queen's University General Research Ethics Board and the __________ District School Board.

To collect data for the upcoming component of this research, I will be conducting individual interviews, which will take approximately 20 minutes and take place during regularly scheduled class time. The interview will be audio taped. The interview will be transcribed, and then the tape will be destroyed. None of the data will contain the name of your child. Data will be secured in a locked office, and your identity will be kept confidential.

I do not foresee any risks in the research participation of your child. His or her participation is entirely voluntary. Your child is free to withdraw at any time with no effect on his or her standing in school. Your child is not obliged to answer any objectionable or uncomfortable question.

This research may result in publications of various types, including my Master's thesis, journal articles, professional publications, newsletters, books and instructional materials. The identity of your child or the name of their school will not be attached to any form of the data that you provide and will not be known to anyone tabulating or analyzing the data, nor will these appear in any publication created as a result of this research. A pseudonym will replace your name on all data that you provide to protect your identity. If the data are made available to other researchers for secondary analysis, your identity will never be disclosed. Upon request, you may receive the results of the study after its completion.

If at this point, or at any point in the future, should you have any questions about this research exercise, please feel free to contact me at (613) 531-0392 (e-mail: 1jg4@qlink.queensu.ca) or my supervisor, Dr. John Freeman at (613) 533-6000 ext. 77298 (e-mail: freemanj@educ.queensu.ca). For questions, concerns or complaints about the research ethics of this study, contact the Dean of the Faculty of Education, Dr. Rosa Bruno-Jofré at 613-533-6210 or the Chair of the Queen's University General Research Ethics Board, Dr. Stephen Leighton at (613) 533-6081 (e-mail: greb.chair@queensu.ca).

Sincerely,

Jovan F. Groen
M.Ed. Candidate
Faculty of Education
Queen's University

Jovan Groen
M. Ed. Candidate
Faculty of Education
Queen's University

Title: Interest in the Elementary Science Classroom

I have read and retained a copy of the letter of information for interview concerning "Interest in the Elementary Science Classroom." My questions have been sufficiently answered. I am aware of the purposes and the procedures of the study and I have been informed that the interview will be recorded by audiotape. I understand that my child's participation is voluntary, and that she/he may withdraw and her/his data removed at any time with no consequences to her/his standing in school. I have also been informed of the steps that will be taken to ensure the confidentiality of all information.

I am aware that if I have any questions about this research exercise, I am free to contact Mr. Jovan Groen at (613) 531-0392 (e-mail: 1jg4@qlink.queensu.ca) or his supervisor, Dr. John Freeman at (613) 533-6000 ext. 77298 (e-mail: freemanj@educ.queensu.ca). I am also aware that for questions, concerns or complaints about the research ethics of this study, I can contact the Dean of the Faculty of Education, Dr. Rosa Bruno-Jofré at 613-533-6210 or the Chair of the Queen's University General Research Ethics Board, Dr. Stephen Leighton at (613) 533-6018 (e-mail: greb.chair@queensu.ca).

Child's
name:____

Signature of
Parent/Guardian:____

Date:_______________________________________

Please write your e-mail or postal address at the bottom of this sheet if you wish to receive a copy of the results of this study.

APPENDIX D: STUDY QUESTIONNAIRE

Science Interest Questionnaire

Please check the appropriate box in each case:			
Are you a	Boy ☐	Girl ☐	
Grade:	Four ☐	Five ☐	Six ☐

Please check <u>ONE</u> box for each answer

Statements	**Strongly Disagree**	**Disagree**	**Not Sure**	**Agree**	**Strongly Agree**
I look forward to science class.					
I like science.					
I like watching science shows on TV.					
Science is boring.					
It is very important to learn about science.					
I enjoy science books or articles.					
Science is too hard.					
Science is fun.					

How OFTEN do you do each of the following in science class?
Please check ONE box for each answer

Statements	**Interest Scale**				
	Not at All	**Not Very Often**	**Some-what Often**	**Very Often**	**Extreme ly Often**
Doing science experiments.					
Working with a partner in science class.					
Doing written work in science class.					
Watching my teacher show me things in science.					
Exploring and working on science with others.					
Measuring things and using special tools when doing science.					
Watching my teacher do a demonstration.					
Working on handouts in science class.					
Talking and sharing our ideas about a science topic.					
Making things in science.					
Reading about science in class.					
Working on science projects as a group.					
Watching my teacher do a science experiment in front of the class.					
Copying things from the board in science class.					
Looking at things my teacher brings into the class for science.					
Working with my hands in science class.					

How INTERESTED are you in each of the following?
Please check ONE box for each answer

Statements	Interest Scale				
	Not at All	Not Very	Some-what	Very	Extreme ly
Doing science experiments.					
Working with a partner in science class.					
Doing written work in science class.					
Watching my teacher show me things in science.					
Exploring and working on science with others.					
Measuring things and using special tools when doing science.					
Watching my teacher do a demonstration.					
Working on handouts in science class.					
Talking and sharing our ideas about a science topic.					
Making things in science.					
Reading about science in class.					
Working on science projects as a group.					
Watching my teacher do a science experiment in front of the class.					
Copying things from the board in science class.					
Looking at things my teacher brings into the class for science.					
Working with my hands in science class.					

How interested are you in each of the following?
Please check ONE box for each answer

Topics	Interest Scale				
	Not at All	Not Very	Somewhat	Very	Extremely
Magnets					
Weather					
Plants					
Pulleys and gears					
Space					
Animals					
Light					
Rocks and minerals					
The environment					
Healthy living					
Electricity					
Sound					

APPENDIX E: INTERVIEW QUESTIONS

When did you last have science class? What did you do?

What parts of science class do you like the most? Why?

What parts of science class do you like the least? Why?

What do you think is the best way to learning science? Why?

What was the most interesting thing you have done in science class this year?

What makes science class interesting? Why?

If you were the teacher, how would you make science topics and tasks interesting for your students?

APPENDIX F: DESCRIPTIVE STATISTICS

Individual Interest Items	Mean	SD	Skewness	Kurtosis
1. I look forward to science class.	3.55	1.00	-.44	-.43
2. I like science.	3.80	1.00	-.83	.49
3. I like watching science shows on TV.	3.50	1.21	-.46	-.66
4. Science is boring. (reversed)	3.95	1.07	-.85	.02
5. It is very important to learn about science.	4.14	.88	-.99	.97
6. I enjoy science books or articles.	3.11	1.08	-.19	-.61
7. Science is too hard. (reversed)	4.04	.93	-.82	.29
8. Science is fun.	4.02	1.03	-.98	.49
Situational Factor Frequency Items				
1. Doing science experiments.	2.81	.83	.12	.64
2. Working with a partner in science class.	2.96	1.06	.35	-.82
3. Doing written work in science class.	3.98	.88	-.67	.13
4. Watching my teacher show me things in science.	3.44	1.08	-.23	-.83
5. Exploring and working on science with others.	2.75	.94	.39	-.07
6. Measuring things and using special tools when doing science.	2.71	1.00	.10	-.59
7. Watching my teacher do a demonstration.	3.25	1.06	-.02	-.91
8. Working on handouts in science class.	3.68	1.05	-.47	-.61
9. Talking and sharing our ideas about a science topic.	3.35	1.03	-.01	-.60
10. Making things in science.	2.62	.95	.83	.22
11. Reading about science in class.	3.31	1.13	-.12	-.90
12. Working on science projects as a group.	2.70	1.06	.48	-.25
13. Watching my teacher do a science experiment in front of the class.	2.79	1.08	.34	-.51
14. Copying things from the board in	3.34	1.18	-.11	-.93

science class.				
15. Looking at things my teacher brings into the class for science.	2.62	1.06	.69	-.24
16. Working with my hands in science class.	2.72	1.20	.49	-.69
Situational Factor Interest Items				
1. Doing science experiments.	4.35	.87	-1.44	2.03
2. Working with a partner in science class.	3.93	.95	-.69	-.01
3. Doing written work in science class.	2.25	1.05	.59	-.12
4. Watching my teacher show me things in science.	3.24	.98	-.16	-.07
5. Exploring and working on science with others.	3.82	.95	-.61	.26
6. Measuring things and using special tools when doing science.	3.67	.99	-.46	-.22
7. Watching my teacher do a demonstration.	3.17	1.00	-.08	-.34
8. Working on handouts in science class.	2.53	1.11	.39	-.53
9. Talking and sharing our ideas about a science topic.	3.20	1.02	-.15	-.42
10. Making things in science.	4.48	.83	-1.84	3.57
11. Reading about science in class.	2.81	1.13	.16	-.58
12. Working on science projects as a group.	3.89	1.04	-.82	.04
13. Watching my teacher do a science experiment in front of the class.	3.28	1.09	-.06	-.63
14. Copying things from the board in science class.	2.06	1.06	.74	-.09
15. Looking at things my teacher brings into the class for science.	3.68	.94	-.35	-.19
16. Working with my hands in science class.	4.22	.89	-.99	.39