Understanding How Ontario High School Science Teachers Perceive and Foster Creativity

By

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Abstract

Creativity is interrelated with many key characteristics necessary for personal and social prosperity; however, there is an absence of a working definition and instructions on how to enhance or assess creativity in Ontario policy and curriculum documents. Because science is a subject that many people perceive as uncreative, the purpose of this qualitative study is to explore how Ontario secondary school science teachers perceive and work to foster creativity. This research uses a purposeful sample interview of two Ontario secondary school science teachers about fostering creativity in the classroom. Findings are drawn from analysis using open-ended coding strategy resulting in themes across the data set. Findings indicate that participants demonstrate similar understanding of science creativity but articulate different definitions thereof, believe that the majority of students lack creativity in their science class, experience more constraints than support in teaching for creativity, and use different strategies in the classroom to foster science creativity. The implications for the broad educational community includes the need for a modification of the science curriculum in Ontario to incorporate a greater emphasis on teaching for creativity as opposed to content and the support needed from administrative staff for science teachers to foster science creativity. This research will also guide my practice when I enter into a classroom as a science teacher in fostering creativity.

Key Words: science education, creativity, high school, teacher perceptions
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Chapter One: Introduction

1.0 Research Context

The study of creativity in education developed over the past 60 years with four distinct themes (Saebo, McCammon, & O’Farrell, 2007). The preliminary focus of study in the 1950’s was on the genius and giftedness of the individual. In the 1960’s focus shifted to measuring outcomes and testing creative ability related to cognition. In the 1970’s the emphasis was on connecting creativity with imaginativeness and the need to stimulate creativity. Finally, since the 1980’s, research has looked towards environmental conditioning and social theory to understanding the concept of creativity (Saebo et al., 2007). In line with this fourth theme, the focus on creativity is now concerned with ordinary people within the education system (Saebo et al., 2007). MacKinnon (1978) first coined the term ‘big-C creativity’ to refer to the creativity of talented experts in various fields, such as that of Michelangelo or Einstein, which reflects the focus of early researchers. In contrast, the creativity that is demonstrated by the general population was first termed ‘little-c creativity’ (Craft, 2000) or ‘mini-c creativity’ (Kaufman & Beghetto, 2008), which reflects the shift toward studying creativity in ordinary people. For the purpose of this Master of Teaching Research Project, I will be using the little-c creativity framework in understanding the concept of creativity. Due to the complex nature of term creativity, I will further define creativity in the literature review in Chapter Two.

In the Growing Success policy authored by the Ontario Ministry of Education (OME) (2010), one of the categories of the criterion-referenced assessment and evaluation is ‘thinking and inquiry’. This category of thinking entails “[t]he use of critical and creative thinking skills and/or processes” (p. 17). Since this assessment and evaluation framework applies to all subject areas and disciplines in both elementary and secondary schools in Ontario, all students are
required to be assessed on their creative thinking skills in all grades and subjects. *Achieving Excellence: A Renewed Vision for Education in Ontario* policy also published by the OME (2014) states that “[a]chievement … means raising expectations for valuable, higher-order skills like...creativity” (p. 3). Creativity is a skill that employers seek out among graduates (Ontario Ministry of Education, 2014) since it is recognized in promoting global development and economic growth (Pool & Swell, 2007). Action Canada (2012) released a report which states that our country is shifting towards a creative economy, such that Canada “has become a dominant force in today’s world economy” (p. 3). In addition, creativity is interrelated with many key characteristics necessary for personal and social prosperity, which I will further elaborate in my literature review section (Kampylis, Berki, & Saariluoma, 2009; National Advisory Committee on Creative and Cultural Education, 1999).

### 1.1 Research Problem

Surveys of students indicate that there is a lack of appreciation of science as a creative endeavour (Schmidt, 2010). Kim (2011) analyzed the results of the Torrance Tests for Creative Thinking from a sample of 272,599 students from kindergarten to grade 12 across the United States and Canada. Findings showed that, in the past 20 years, students have been showing less creativity, especially children in grades 1 to 6. Since the arts are primarily regarded as aesthetic pursuits while sciences are regarded as rational and logical pursuits, it is not surprising that most people associate creativity within the arts and not the sciences; however, creativity in required for both (Kind & Kind, 2007). Science educators argued that creativity should be a central focus of education programs; however, many felt that there are constraining pragmatic issues (Schmidt, 2010). For example, although Ontario education policies widely use the term ‘creativity’, there is an absence of a working definition and instructions on how to enhance or assess creativity
(Kampylis et al., 2009). Therefore, it is important to understand how science teachers perceive and seek to foster student creativity. However, limited research has studied the educator’s view of creativity and, moreover, only two studies have studied Canadian educators’ views of creativity (Karrow, 1997; Hondzel, 2013).

1.2 Purpose of the Study

The purpose of this qualitative study was to explore how Ontario secondary school science teachers perceive and work to foster creativity. This was achieved through semi-structured interviews with a small sample of these teachers which explored: the resources they use; assessment and evaluation strategies that reportedly promote creativity; self-identified limitations and barriers to fostering creativity in science; and reportedly effective learning and teaching strategies for doing so. Secondary teachers were of particular interest in this study because here marks when students begin receiving instruction from field-specific teachers (Fives, Huebner, Birnbaum, & Nicholich, 2014) including in science.

Findings from this study will be shared with the educational research community and teachers in order to further inform strategies for fostering creativity. I hope the study will provide high school teachers and policy makers at large with insights on how to foster creativity so that more students can appreciate science as a creative endeavour and choose to pursue a higher education in scientific fields.

1.3 Research Questions

The central question that guided my research was: how does a sample of Ontario secondary school science teachers perceive and seek to foster student creativity? Subsidiary questions further guiding this inquiry were:

- How do teachers assess student creativity?
• How much value is being placed on teaching the importance of creative thinking by science teachers?

• What are limitations of fostering creativity in a mainstream classroom environment?

• What learning and teaching strategies do teachers hold to be most successful in fostering student creativity?

1.4 Background of the Researcher

My interest in the topic of creativity in the scientific field stems from my undergraduate experience at the University of Guelph which was where I obtained my Bachelor of Science degree. During my studies there, I worked with Dr. William Bettger on an ongoing project aimed at developing a toolkit for creativity especially for new incoming undergraduate students entering the field of science. This project encouraged me to continually think outside the box and ask unconventional questions in an attempt to seek answers or alternative solutions if one already exists. It allowed me to appreciate the importance of creativity in not just the arts, but also in the scientific field as well.

It wasn’t until my studies in university when I appreciated the idea of science being a dynamic, interdisciplinary and creative endeavour. Growing up and being educated in the Ontario public school system for nine years prior to my undergraduate studies, I developed an interest towards the field of sciences not because I thought it was a creative endeavour, but it was because I excelled in my mathematics and sciences courses where computation, following instructions and memorization constituted a major bulk of marks. Therefore, I felt that the concepts and nature of science were misrepresented in high school as static facts where being able to understand and memorize concept is all it takes to be a ‘good’ scientist. However, seeing
the nature of science in a completely different light in university allowed me to critically question the theories and knowledge in the scientific literature and not just blindly agree with the literature, as well as develop alternative possible answers through creative thinking.

Due to my intrinsic motivation to help others, I am currently at the University of Toronto pursuing a Master of Teaching degree in the intermediate/senior division so I can become a teacher and inspire and guide others in their pursuit to learn science. This degree will allow me to explore how to most effectively foster creativity so that more students can appreciate science as a creative endeavour and choose to pursue higher education in science. In the future as a certified teacher, I hope to employ these teaching strategies in my classrooms.

1.5 Overview of the MTRP

I conducted a qualitative research study using purposeful sample interview of two Ontario science teachers about fostering creativity in the science classroom to answer the research questions. In Chapter Two, I review research literature on current understanding of creativity and the recent emphasis that institutions are placing on creativity. In Chapter Three, I elaborate on the research design. In Chapter Four, I report my research findings and discuss their significance in light of the existing research literature. In Chapter Five, I identify the implications of the research findings for my own teacher identity and practice, and for the educational research community more broadly. I also articulate a series of questions raised by the research findings and point to areas for future research.
Chapter Two: Literature Review

2.0 Introduction

In this chapter, I review the literature in the areas of creativity, perceptions of high school science teachers with regards to creativity, and pedagogical approaches to fostering creativity. More specifically, I review findings related to how teachers understand and in turn foster creativity through differing pedagogical approaches and teaching methods. I start by defining the term creativity as it appears in literature and I consider how this term is manifested in education, in high school and in the sciences. Next, I identify teachers’ perceptions of creativity reported in literature in order to contextualize the concept of creativity within the scope of education. Finally, I overview some pedagogical practices and teaching methods from research on fostering creativity.

2.1 Defining Creativity

The term creativity is used in various contexts, from scientific literature to government documents to daily speech. In Ontario education policy (Ontario Ministry of Education, 2010; 2014), this term is used as a positive attribute of achievement, and teachers are required to evaluate student creativity. However, the problem lies in understanding the ill-defined term within the given context of the curriculum as there is no working definition provided in evaluating and assessing creativity (Kampylis et al., 2009). Even within scientific literature, there is little consensus on one definition that captures the essence of this multifaceted concept (Hu & Adey, 2002). The absence of a working definition results in teachers lacking motivation towards the realization of creativity in schools (Kampylis et al., 2009). Many scientists have attempted to define this abstract term, each with its own variation of what this term means; however, it is commonly agreed that creativity involves generating novel and useful ideas or
products (Mumford, 2003). As a result, the term creativity is often associated with innovation; however, creativity is distinguished from innovation as it is the process of mentally developing new ideas, whereas innovation refers to the product or process of making new things (Hondzel, 2013).

To understand the complexity of creativity, many related traits have been studied and deemed as being “creative”, such as verbal fluency, metaphorical thinking, flexible decision making, tolerance of ambiguity, willingness to take risks, autonomy, self-confidence, problem finding, ideational fluency and belief in oneself (DeHaan, 2009). Since there is not one trait that can define all parameters of creativity, DeHaan (2009) defines the creative act as “not a singular event but a process, an interplay among several interactive cognitive and affective elements” (p. 173). Therefore, with regards to defining creativity in the realm of education for the rest of this research paper, I will define creativity as the multicomponent process involving the generation of novel ideas or products. Historically, researchers studying creativity through the focus of big-c creativity defined “novel” as a product that is new and meaningful to society; however, I am particularly focused on the little-c concept of creativity in defining “novel” to be “thinking in identifiably unique ways when they meet everyday problems in real-life situations” (Ripple, 1989, p. 189).

2.1.1 Creativity in education. Creativity is considered essential for personal and social prosperity in the creative age of information, communication and collaboration that we live in (Kampylis et al., 2009). As a result, interest of creativity in education began in the late 1990’s throughout the world (Shaheen, 2010). In 1999, the British National Advisory Committee on Creative and Cultural Education (NACCCE) (as cited in Saebo et al., 2007) released a report titled All Our Futures which states that integration of creativity in teaching and learning is
essential in order for education systems to be world-class, which influenced education policies in many countries. Therefore, due to many factors including rapid societal changes, global economic restructuring and technology development, educational systems world-wide are being reformed to be able to adapt to the current changes (Kind & Kind, 2007). Today, the concept of creativity in education is being universalized (Saebo et al., 2007). Creativity is essential in order to solve problems in a new way, and the challenge of school is to shift the focus of capable thinkers to take on new initiatives instead of merely repeating the results of past generations (Saebo et al., 2007). Creative education trains students to be flexible and handle changes in their working lives so as to meet the unpredictable demands of the future (Kind & Kind, 2007).

2.1.2 Creativity in high school. Creativity can appear differently at various ages of mental and moral development. Lawrence Kohlberg (1971) described the stages of moral development into 3 phases: pre-conventional, conventional, and post-conventional. In the post-conventional phase, individuals are able to define moral values and principles with validity and application beyond the views of the authority (Kohlberg, 1971). The post-conventional phase as described by Kohlberg’s stages of moral development starts from about 12 years old, which include students in high school, and this is when students are able to engage in the process of producing relevant and effective novelty by transcending external constraints and conventional values (Vijayshri & Garg, 2002). In addition, in high school, the range of activities gradually expand and include exposure to more complex concepts which students are encouraged to explore beyond the four walls of the school (Vijayshri & Garg, 2002). As a result, due to their moral development and environmental opportunities, high school students are given chances to demonstrate their creativity.


2.1.3 Creativity in science. The public perception of science is often that it is not a creative endeavour (Schmidt, 2010). However, ‘doing science’ goes beyond mastering an existing body of knowledge or being able to follow set procedures, and by definition it requires going beyond existing knowledge and techniques in order to create new understanding (Hu & Adey, 2002). Hu and Adey (2002) found that scientific creativity is an ability distinct from other kinds of creativity in that it is concerned with scientific experiments, problems, and activities that depend on scientific knowledge and skills through a combination of static and developmental structure. Scientific creativity is important in the education of students because to those who will become scientists and to those others in different fields, understanding the works of scientists is part of their general understanding of society (Hu & Adey, 2002). In order to develop scientific creativity in education, Kind and Kind (2007) set out two criteria. The first criterion for fostering scientific creativity is that school science should be based on what ‘real’ scientists do to reflect aspects of creativity needed in scientific research. The second criterion involves approaching scientific creativity through a framework appropriate to the student’s needs and abilities.

The definition of creativity in terms of general creativity, creativity in education, high school, and science as set out by this section of the literature review will carry forward into the rest of the paper. With this understanding of creativity, the next section of the literature review will discuss teachers’ perception of creativity.

2.2 Teacher Perceptions of Creativity

There is no doubt that teachers have a certain influence on the development of a student. In a survey conducted by Kampylis et al. (2009), over 98% of perspective teachers and in-service teachers agreed that the role of a teacher includes facilitation of student creativity, which is
consistent with 98% of the Cypriot teachers surveyed by Diakidoy and Kanari (1999). However, a teacher’s incorporation of creativity in a classroom is dependent on their perception of creativity; this perception can include certain limitations that hinder them from fostering creativity in the classroom (Kampylis et al., 2009). In understanding how teachers foster and promote creativity in the classroom, it is important to understand how teachers perceive the concept of creativity. Due to the limited extant literature on the perception of teachers in the Canadian context as mentioned in Chapter One, literature from other countries is used below in order to help understand how individuals in this profession perceive creativity.

2.2.1 Development of creativity. Esquivel (1995) emphasizes the role of the environment and sociocultural factors over genetics in the development of creativity. It is a commonly accepted belief that creativity should be a basic component of teachers’ profession (Diakidoy & Kanari, 1999; Storm & Storm, 2002). To support this view, a study by Fryer and Collings (1991) with 1028 British and Welsh educators reported that 89.6% believed creativity can be developed in every person. In an American context, Fleith (2000) reported a similar 90% of educators believing that creativity could be developed. In a more recent study, 85.3% of in-service teachers in Greece reported similar perceptions (Kampylis et al., 2009). However, 28.1% of prospective and in-service teachers in the Greek study did not think that creativity can be taught (Kampylis et al., 2009), which contradicts the idea that creativity can be taught and is not an innate characteristic (Sternberg, 2008; DeHaan, 2009). In addition, despite many teachers believing student’s creativity can be developed in the classroom, not all teachers consider that they are responsible for its development (Aljughaiman & Mowrer-Reynolds, 2005).

2.2.2 Training and resources. Kampylis et al. (2009) reports that more than 50% of prospective teachers and in-service teachers surveyed felt that they are not well-trained to act as
facilitators of students’ creativity. Due to a lack of training and understanding of the concept of creativity, some teachers may lack confidence in facilitating creativity (Turner, 2013). Therefore, more training is necessary in order for teachers to optimally foster the complexity of creativity (Manning, Glackin, & Dillon, 2009). Time and resources, such as textbooks, have also been found to limit a teacher’s ability to foster creativity (Kampylis et al., 2009). Nicholl and McLellan (2008) found that there are time constraints to cover specific content at the secondary level which can limit time for creative activities.

Therefore, despite beliefs by many teachers that the development of creativity can be taught in a classroom, there appears to be certain limitations as outlined by teacher surveys that hinder such development from occurring. In the next section of the literature review, I discuss pedagogical strategies for fostering creativity as reported in research literature.

2.3 Fostering Creativity

Beyond what has already been mentioned in this research paper, a challenge of fostering creativity for teachers is that creative teaching is an art with no fail-safe recipe or routine (Saebo et al., 2007). Teachers cannot be taught didactically how to be creative; however, there are strategies and approaches that can help teachers promote creative thinking (Saebo et al., 2007). In this section of the literature review, I will outline some key personal characteristics of a teacher that have been found to make them creative, and then distinguish between ‘creative teaching’ and ‘teaching for creativity.’ The former can be seen as a means of achieving an end, which is ultimately teaching for student creativity. Creative teaching is regarded as an important component of good teaching which is necessary for and can therefore lead to teaching for creativity, but it does not always necessarily translate to the development of creativity in students (Saebo et al., 2007). As a result, creative teaching is context-dependent and is simply how a
teacher manages and organizes learning, which leads to the more important questions of how to best teach for student creativity. In addition, I will outline some key characteristics of a creative learning environment that can help foster student creativity.

2.3.1 Teacher personal characteristics. Certain personal characteristics of teachers have been shown to elicit more teacher creativity. Bramwell, Reilly, Lilly, Kronish, and Chennabathni (2011) found that there must be a degree of personal ownership by the teacher in their profession in order for teachers to feel and be creative. Teacher creativity is also dependent on successful interaction with demands of communities in which teachers live and work (Bramwell et al., 2011). In addition, teachers who are intrinsically motivated, hard-working, persistent, passionate about their work, risk-taking and value intellectual activity have been found to be more creative (Bramwell et al., 2011). However, when it comes to risk-taking, even experienced creative teachers sometimes experience failures (Bramwell et al., 2011), which is why research has also found that teachers dislike certain traits that are associated with creativity such as risk-taking and impulsivity (Kampylis et al., 2009).

2.3.2 Creative teaching. NACCCE (1999) defines creative teaching as “teachers using imaginative approaches to make learning more interesting, exciting and effective” (p. 102), which is simply a characteristic of teaching. There is a large volume of findings in literature outlining different creative teaching strategies. The following is a list of differences cited in literature between creative teaching strategies and traditional uncreative teaching, respectively: open-ended problems vs. closed problems (Schamel & Ayres, 1992), cooperative learning vs. individual learning (Anderson, 2001), student-oriented vs. teacher-oriented (Melar, 1993), group work vs. individual work (Marazzi, 1999), explorative tasks vs. close-ended tasks (Saxon, Treffinger, Young, & Wittig, 2003), open investigation vs. recipe work (Sallam & Krockover,
1982), hands-on teaching vs. lectures (Shymansky & Penick, 1981), outdoor activities vs. classroom activities (Boss, 2001), project work vs. lectures, (Mackin, 1996), and issue-oriented vs. concept-oriented (Penick & Yager, 1993). Many of the creative teaching strategies mentioned here are in line with the idea that science learning should be based on real-world contexts and problem-based instructions where students have the ability to explore versus on conventional memorization (DeHaan, 2008). Additionally, these teaching strategies mentioned here innately result in fostering student creativity which I will address in the next section when I talk about teaching for creativity.

2.3.3 Teaching for creativity. Teaching for creativity entails fostering student creativity where creativity is the anticipated learning outcome (Kind & Kind, 2007). Teachers who fulfill the main principles of encouraging students to explore their creative potential in confidence, identifying student’s creative strengths in different areas, role modeling the process of being creative, and adopting a learner-inclusive approach to pedagogy have been found to be able to develop the creative abilities of students (Saebo et al., 2007).

It is mentioned by students in a study by Kampylis et al. (2009) that there needed to be more hands-on activities within their science classes. Students in science should have the experience of exploring laboratory experiments and other hands-on activities involved in science, which can also take on the form of open-ended vs. recipe tasks (Kind & Kind, 2007). Open investigative practical work has been found to enhance students’ creative thinking as they were able to combine old ideas in new ways, exploring within the rules of the domain, and allowing changes to the rules of the conceptual space (Haigh, 2007).

2.3.4 Creative learning environment. Davies and Gilbert (2003) identified six key characteristics of creative learning environments which foster individual student creativity or
group creativity. These characteristics include an environment where there is: a trusting relationship where students feel like they are able to take risks and learn from failure; freedom of action where students are able to make choices over how and what they do; variation of context where the students can make practice making connections in a range of different contexts; balance between skills and challenge in which students are engaged at the right level of activities that require a mix of skills to meet them; interactive exchange of knowledge and ideas where students can draw on diverse sources of information; and real world outcomes (Davies & Gilbert, 2003). Therefore, based on findings from research, a classroom environment that incorporates these six key characteristics will allow greater opportunity for students to develop creativity.

Although the research literature suggests many ways for teachers to foster student creativity, with many aspects of the teaching profession, it requires professional judgment and experience, as teaching is a dynamic and context-dependent process.

2.4 Conclusion

In this literature review I reviewed research on the definition of creativity in general and in the context of education, in high school, and in the sciences. In addition, I reviewed findings on teacher perceptions of creativity including on whether it can be developed and taught; this provides insight into the value teachers place on fostering creativity. Finally, I outlined research on different pedagogical approaches and teaching methods of fostering creativity.

This review elucidates the extent that attention has been paid to incorporating creative teaching strategies that ultimately foster student creativity in science education. It also raises questions about how teachers can be supported in their efforts to promote a classroom that fosters creativity and points to the need for further research in the areas of concretely defining the vague term of creativity in education documents and providing tangible resources and
instructions on how to best foster creativity. In light of this, the purpose of my research is to learn how teachers perceive creativity in science education so that limitations can be removed that would otherwise limit a teacher’s ability to foster creativity. Therefore, through interviewing teachers in this area, I can better understand their perceptions toward and some barriers to fostering creativity and aim to provide the educational community at large with insights on how to foster creativity. In Chapter Three, I will further describe the methodology involved in collecting and analyzing the data gathered through teacher interviews.
Chapter Three: Research Methodology

3.0 Introduction

This chapter outlines the research methodology for conducting my study. I begin with identifying and justifying the research approach and procedures. Next, I describe the instrument of data collection which is the qualitative semi-structured interview. Then, I identify my research participants, including the sampling criteria I used and the sampling procedure, and providing short descriptions of the participants. In the next section of this chapter, I describe how the collected data was analyzed. Next, I proceed to discussing some ethical risks associated with qualitative interview research and ways to mitigate these risks in relation to my research. Finally, I outline strengths and limitations of the qualitative interview for my topic.

3.1 Research Approach and Procedures

Research can be classified as quantitative or qualitative depending on the problem or issue leading to the study, the central purpose of the study, and the research question (Creswell, 2007). For the purpose of my research study, a qualitative approach involving a literature review and semi-structured interviews with teachers was conducted. When comparing quantitative and qualitative, neither approach is superior to the other as they each serve a different purpose and answer different kinds of research questions (Carr, 1994). The purpose of quantitative research is the answer ‘what?’ questions, while qualitative research attempts to answer ‘how?’ and ‘why?’ questions (Marshall, 1996). Moreover, quantitative research relies on numerical data and fixed questions in an attempt to establish correlation between given variables and outcomes (Choy, 2014), whereas qualitative research relies on in-depth responses from individuals in an attempt to understand and interpret social constructs at a specific point in time given specific contexts (Merriam, 2002). In addition, qualitative research can be broadly classified as the exploration of
meaning and understanding constructed by humans in a social interaction with the world (Merriam, 2002). Since social experience is dynamic, interpretation and construction of reality is non-static and can change over time (Merriam, 2002), which contrasts with quantitative research which is characterized by the ability for data to be replicated (Choy, 2014).

Based on my problem, purpose, and central research question, qualitative research was most appropriate as it allowed me to examine in detail each case that arises in the natural flow of social life (Choy, 2014). Although the topic of creativity has been measured using quantitative tests such as the Torrance Test of Creative Thinking (Torrance, 1966), the purpose of my study was to understand the experiences and perspectives of the teacher participants through an interpretive and humanistic lens (Jackson, Drummond & Camara, 2007). Through the use of a qualitative interview approach, I was able to answer my research question of ‘how high school science teachers perceive and seek to foster student creativity’ by drawing on teacher experiences and thoughts. Therefore, the best approach to conducting my research was qualitative, specifically through using the semi-structured interview as a tool of data collection.

3.2 Instruments of Data Collection

The field of qualitative research is broad and uses a range of different data collection methods (Jacob & Furgerson, 2012). Creswell (2007) states that all data falls into one of four categories, which are observations, interviews, documents, and audiovisual materials. However, despite all these different methods of data collection, the one commonality among them is the desire to expose the human part of a story (Jacob & Furgerson, 2012). For the purpose of my study, the primary instrument for data collection was semi-structured interview protocol which was recorded and transcribed. This method was employed to facilitate pre-determined topic-
specific questions while allowing improvised follow-up questions to further explore areas of interest and significance that emerge (Arksey & Knight, 1999).

An interview is a method of data collection in which one person asks questions of another person either face to face or by telephone (Whiting, 2008). Interviews can be differentiated by the design, ranging from structured, which often produces quantitative data, to unstructured, with semi-structured interviews in the middle of the range with characteristics of both ends of the spectrum (DiCicco-Bloom & Crabtree, 2006). Some key features of semi-structured interviews which is in-line with my protocol is that it usually last from 30 minutes to several hours, is scheduled in advanced at a designated time, takes place at a location outside of everyday events, organized around a set of pre-determined questions, and engages other questions that emerge from the dialogue (Whiting, 2008).

For my study in particular, interviews were approximately 60 minutes in length. My pre-determined questions are found in appendix B. To answer my research questions (see section 1.3), I divided my interview into five distinct sections: background information, in-class teaching practices, beliefs and values, influencing factors, and next steps. The initial phase of collecting background information allowed the participant to begin answering simple questions which aided in the process of building a rapport between the interviewer and the participant; this in turn involved trust and respect for the participant and the information they shared (DiCicco-Bloom & Crabtree, 2006). For example, questions asked in this section of the interview included: How many years have you worked as a teacher? How many years have you been teaching at this school? The next sections gradually delved deeper into the topic of creativity starting with the participant’s regular teaching practices, then questions about their beliefs and values. Next were
some questions about some influencing factors, and finally questions about next steps wrapped up the interview.

3.3 Participants

In this section, I identify the sampling criteria and sampling procedures I used in identifying my participants. I also provide a brief description of my participants.

3.3.1 Sampling criteria. The following is a list of sampling criteria applied to each participant:

1. Participants have five years of practical experience in the profession of teaching in Ontario.
2. Participants report intentionally seeking to foster students’ creativity through their curriculum and instruction.
3. Participants must have taught secondary science courses (including general science, biology, chemistry, or physics).

This list was generated in order to narrow down potential candidates for my particular study as it is not practical, efficient or ethical to study a whole population (Marshall, 1996). Instead of using a random sample, for a qualitative study it is more appropriate to have this list of sampling criteria because a random sampling strategy best provides results that generalize to the population, but it is not the most effective way of understanding a complex research topic (Marshall, 1996). Participants had at least five years of practical experience in order to ensure a minimum level of development in the teaching and practice of different teaching strategies. As my study is relates to how teachers perceive and foster creativity, my participants are to self-identify as being a “creative teacher”, in whatever sense of the word they see the word “creative”
to mean. Also, since my research is targeted to fostering creativity in science classes, my participants also must have taught science or any streams in the sciences.

3.3.2 Sampling procedures. Qualitative studies generally tend to have a small sample with a goal of understanding the complex issues relating to human behaviours (Marshall, 1996). Several sampling procedures to selecting a sample for a qualitative study include convenience sampling, judgment sampling, and theoretical sampling. Convenience sampling involves selecting the most accessible subjects; judgment sampling – which is sometimes called purposeful sampling – involves selecting the most productive sample to answer the research question; and theoretical sampling involves interpreting theories from emerging data and selecting new participants to examine and elaborate on the theory (Marshall, 1996).

For my research, I employed a mixed sampling strategy of convenience and judgment sampling. Judgment sampling is the most common sampling technique for qualitative studies (Marshall, 1996), and I chose to employ judgment sampling in order to select participants to represent my predefined sampling criteria and traits as I mentioned in the previous section (Luborsky & Rubinstein, 1995). In addition, due to the small-scale nature of the study and the methodological parameters I am working within, I employed a convenience sampling method as well. Being immersed in a community of teacher colleagues, candidates and mentors, I relied on my existing contacts and network to recruit my participants. In addition, as a teacher candidate with limited time and monetary resources, convenience sampling is an appropriate method as it is the least costly in terms of time, effort and money (Marshall, 1996).

3.3.3 Participant biographies. The first participant has the pseudonym of Mr. Singh, and he normally teaches grades 8 to 12. For grade 8, he teaches math, and for grade 9 and 10, he teaches science. Mr. Singh graduated from a concurrent teacher education program in the
province of Ontario with the teachables in biology and chemistry, and he majored in life science in his undergraduate studies. As of the interview, Mr. Singh had taught for five years, all of which are at a private school located in the Greater Toronto Area.

The second participant has a pseudonym of Mrs. Scarlet, and she normally teaches grade 9 to 12. For grade 9 and 10, she teaches academic and applied sciences, and she also teaches the grade 11U and 12U biology and chemistry courses. Mrs. Scarlet graduated in a concurrent teacher education program in Ontario, and received her Bachelor of Science Honours and Bachelors of Education in 2008. As of the interview, Mrs. Scarlet had taught in the same a public secondary school board in the Greater Toronto Area since graduation.

3.4 Data Analysis

Qualitative data analysis is a complex process that involves organizing data, conducting a preliminary read-through of the database, coding and organizing themes, representing data, and forming interpretations (Creswell, 2013). Ideally, qualitative data analysis occurs concurrently with data collection (DiCicco-Bloom & Crabtree, 2006); therefore, it is important for qualitative researchers to understand these processes and be engaged in active analysis throughout all phases of the research (Thorne, 2000).

Since a semi-structured interview protocol was employed for my research, the data needed to be prepared and organized by initially transcribing the audio into texts (Creswell, 2013). Data was then reduced into themes through a process of coding, which involved condensing text into small categories of information that were in-line with my guiding research questions (Creswell, 2013). Finally, I interpreted the data by abstracting out the larger meaning of the data beyond the codes and themes (Creswell, 2013).

3.5 Ethical Review Procedures
Ethics in research pertains to doing good and avoiding harm (Orb, Eisenhauer, & Wynaden, 2001). However, ethical issues arise in all kinds of research, including qualitative interview research that I conducted; therefore, it was important to reduce and prevent harm through the implementation of appropriate ethical principles (Orb, Eisenhauer, & Wynaden, 2001). Although scripts and questions were carefully designed, there were some elements of unanticipated risk that could lead to harm in an interview. In the act of listening, the interviewer may inadvertently reflect and convey personal information back to the participant which can result in unintended harm (DiCicco-Bloom & Crabtree, 2006). Secondly, anonymity of the participant’s information must be maintained as participants may share information that could jeopardize his or her position outside of the interview (DiCicco-Bloom & Crabtree, 2006). Finally, there should be adequate communication provided to the participant about the nature of the study (DiCicco-Bloom & Crabtree, 2006).

Given my research topic of creativity, there were no foreseeable risks to participating in this study; however, the ethical principle of beneficence, which is defined as “doing good for others and preventing harm” (Orb, Eisenhauer, & Wynaden, 2001, p. 95) is still adhered to. In addition, participants were also asked to give their consent to be interviewed and audio-recorded by signing a consent letter (see appendix A), which provided an overview of the study, addressed ethical implications, and specified expectations of participation.

Participants have the right to privacy, anonymity, and confidentiality; therefore it is an ethical duty for researchers to keep participants and their information anonymous (Whiting, 2008). Burns and Grove (2005) argue that true anonymity only exists when not even the researcher can link the data to the participant’s identity; however, this cannot be achieved through face to face interviews. Although true anonymity cannot be ensured, efforts to keep the
data confidential were taken to protect the participants, such as assigning participants with a pseudonym, and excluding any identifying markers related to their schools or students. Moreover, all data is stored on a password protected device and will be destroyed after 5 years.

Respect is another ethical principle that is adhered to, which is recognized in the participant’s “right to be informed about the study, the right to freely decide whether to participate in a study, and the right to withdraw at any time without penalty” (Orb, Eisenhauer, & Wynaden, 2001, p. 95). To maintain this ethical principle, participants was notified of their right to withdraw from participation in the study at any stage of the research study, and they had the right to refrain from answering any questions that they do not feel comfortable with.

These ethical principles and duties are outlined to mitigate any ethical issues that might arise, but interviews are a dynamic process where unforeseen predicaments might arise (DiCicco-Bloom & Crabtree, 2006); therefore, my professional judgment was also used to maintain a comfortable and safe research environment for the participants.

3.6 Methodological Limitations and Strengths

Research methodology – whether quantitative or qualitative – is not perfect and contains both limitations and strengths (Choy, 2014). One limitation of qualitative interview methodology is that it requires a lengthy process of collecting, transcribing, organizing and coding, and interpreting the data (Creswell, 2013). Another limitation is that interpretation of the data is limited by the researcher’s personal experience and knowledge which can influence the observation and conclusions that are drawn (Choy, 2014). Moreover, important issues could be overlooked because qualitative interview is generally open-ended, allowing participants to have more control of the content of the data collected (Choy, 2014). Ethical parameters that was approved for the Masters of Teaching Research Project (MTRP) also limited interviews with
teachers only, thus limiting data collection and preventing student or parental perspectives from being included, which plays into how this topic is interpreted. Finally, data about teacher practices collected through qualitative interviews is second-hand and cannot be objectively verified (Choy, 2014). Since only a limited number of teachers are permitted to be interviewed under the MTRP ethical parameters, although findings can provide insight and inform about the topic of creativity, findings cannot be generalized more broadly.

Despite these limitations, there is strength to qualitative interviews. Although the lack of objectivity can be seen as a limitation, qualitative research can provide an understanding of social constructs through an in-depth response from individual experience, which is the purpose of qualitative methodology (Merriam, 2002). Moreover, a semi-structured interview protocol allow for more depth than a survey and provides participants with the ability to speak to what matters most to them as questions are generally open-ended (Choy, 2014). Follow-up question could also be asked by the researcher to explore areas of interest that emerge during the interview (Arksey & Knight, 1999). Additionally, through an interview, teachers have the opportunity to reflect on their practice and articulate their understanding of the topic of creativity in theory and in practice, and allowed me to probe for underlying values, beliefs, and assumptions about the topic (Choy, 2014). Although there were limitations to qualitative interview, the strengths of this research methodology allowed me to answer the research questions that I posed.

3.7 Conclusion

This chapter outlined the methodology that I employed in conducting my research study. I first compared the difference between a quantitative and qualitative research and identified why my research is best suited using a qualitative research method. Next, I discussed why I
employed the semi-interview protocol for my research, and how I used it to address my guiding research questions. Then, I provided the sampling criteria I used to identify potential participants and the sampling procedures I used to find my participants, with a brief description of the participants in my study. I proceed to discussing about how I analyzed my data by transcribing, coding and interpreting. Subsequently, I reviewed the ethical procedures to address any ethical issues and implications involved while I conducted my research. Finally, I identified the methodological limitations and strengths of the research study. In the next chapter, I report the research findings for this study.
Chapter Four: Research Findings

4.0 Chapter Introduction

The importance of conducting this research was outlined in Chapter One as I pointed out to the lack of working definition within ministry document for teachers to properly conceptualize the complex idea of creativity within the works of science education. In Chapter Two, research literature on creativity and science education was consulted on the definition of creativity as it applies to education, high school, and science, perspectives of teachers on the topic of science creativity, limitations of fostering student creativity, and finally pedagogical approaches for fostering creativity. In the previous chapter, leading into this chapter, I described the research methodologies which guided my qualitative semi-structured interviews in which I used to collect my data, including my sampling criteria and the reason for using judgment and convenience sampling for my sampling procedure. Furthermore, I described the procedure for analyzing the data and the limitations and strengths of this study. In this chapter, I will be highlighting the prominent themes that emerged from the analysis of the collected data. The research findings highlighted in this chapter will address the research question: how does a sample of Ontario secondary school science teachers perceive and seek to foster student creativity? Moreover, relations between my research findings and the extant literature as presented in Chapter Two will be made. Several themes emerged from analyzing my data which will be presented in this chapter in the following order:

1. Teachers demonstrate similar understanding of science creativity but articulate different definitions thereof

2. Teachers believe that the majority of students lack creativity in science class
3. Teachers experience more constraints than support in teaching for creativity in the science classroom

4. Teachers attempt to foster science creativity in the classroom using different strategies

For each theme, I will provide a brief description, highlight my research findings and discuss the significance of my research findings within the context of the extant literature. In conclusion of this chapter, I will summarize the key findings and transition to Chapter Five.

4.1 Teachers Demonstrate Similar Understanding of Science Creativity but Articulate Different Definitions Thereof

The teacher participants in my study demonstrated similar understandings that science is a creative endeavour and narrate similar experiential narratives; however, they articulated different definitions when asked what their definition of science creativity means to them. Therefore, it is important to first understand how each participant defined creativity in science and other characteristics they associated with science creativity. The issue of a consistent definition for creativity is not only demonstrated between my teacher participants, but even research literature on creativity has a varying range of definitions (Mumford, 2003; Sternberg, 2008; DeHaan, 2009).

Consistent with the literature review, both science teachers agreed that science is a creative endeavour. However, despite this common belief, there was a difference in how each participant defined science creativity. Mr. Singh defined creativity as:

being able to ... draw from a sense of freedom, freedom of expression, the ability to...look a bit outside the box to really extend beyond more than what you just give them...freedom of incorporating your own self into what you’re doing and extending it...to me creativity, there’s usually something beautiful about it.
From how he defined creativity, he opined that people generally find it easier to express themselves in an artistic form such as paint on a canvas or photo lens compared to science and math which have been subjects that are traditionally viewed as either right or wrong. His definition of creativity is similar to Hu and Adey’s (2002) definition of ‘doing science’. Hu and Adey claim that, by definition, “scientific research requires creativity” because it requires going beyond existing knowledge and techniques in order to create new understanding. As a result, Mr. Singh’s understanding of creativity in science is consistent with literature on science and creativity (Hu & Adey, 2002; Saebo et al., 2007).

Instances of student creativity that Mr. Singh described during the interview further exemplify how he understands and conceptualizes science creativity. He claimed that student creativity that exceeds his expectations significantly usually occurs about once a year. In Mr. Singh’s definition of creativity, he highlighted an element of beauty associated with creativity, and from the examples he highlighted, it resonated with his description of student creativity. He shared with me a project that two students completed in the metabolism unit which included a giant interactive display board, so large that Mr. Singh “had trouble fitting it in the doorway”. During the interview, he showed me a picture of the project and described the different components of the interactive display board and how it related to the whole metabolic process. He described that the project as a:

- giant rotating display. They had these little foam balls and things to represent the number of carbons going through, little ATP stars, they had little slots and trapdoors that would open to represent the proton motor force as they went through the ATP synthase, it was absolutely mind blowing. And needless to say that was easily a level 4...it was just insane how much—I couldn’t fathom how long it must have taken them.
Another example Mr. Singh shared was an assignment he assigned on medical health topic issues. He described a couple students who completed a half an hour documentary about vaccination, which looked at the topic from multiple perspectives. These examples from Mr. Singh’s experience demonstrated that students are capable of stretching beyond the box. Additionally, these examples showed how Mr. Singh saw and appreciated creativity as both examples were masterful visual works of art and media, which related to his definition that there is usually something beautiful about creativity from extending beyond the box.

In contrast to Mr. Singh’s definition of creativity, Ms. Scarlet defined creativity in science as:

being able to come up with a logical way to solve a problem or being able to come up with a way to prove a point. And that is pretty much creativity in science. It’s not like creativity in other subjects where you’re coming up with something out of nothing, creativity in science is often, you know what the end result will look like, or you need to come up with what the end result should look like and you need to find a way to get yourself there.

Her definition differs from Mr. Singh’s definition of creativity as she focused more on solving problems logically and proving them to be true experimentally and Mr. Singh was more focused on expressing oneself freely from extending and thinking “outside the box”. Despite this difference, Ms. Scarlet’s definition is also consistent with Hu and Adey (2002) who define science creativity to be concerned with scientific experiments, problems, and activities that are dependent on scientific knowledge and skills, which is distinct from other kinds of creativity which requires the creation of a medium to express oneself. Ms. Scarlet also emphasized the difference between science as a collection of facts learned through doing science versus science
as an actual idea and concept, the latter which she claimed as being inherently creative. She tries
to make this distinction clear for her students, and her pedagogical approach to teaching science
is related to how she defined science creativity which is “being able to come up with a logical
way to solve a problem or being able to come up with a way to prove a point” and not just
memorizing facts.

Some characteristics that Ms. Scarlet highlighted as important for creativity in science are
inquiry, critical thinking, and problem solving skills which she claimed:

are all kind of inextricably tied together in science because you can’t solve problems in
science without coming up with ways to do it, which is creativity. So they’re all really
linked together in the sciences in particular.

In addition to these characteristics, she also added that “creativity needs to be backed by
logic”. These characteristics and her explanation are all consistent with how she defined
creativity in science, which is linked to coming up with ways to explain concepts in new ways
and coming up with ways to prove things using the scientific method that logically makes sense
and works. This complex interaction of characteristic in understanding creativity is highlighted
by DeHaan (2009) who claims that creative act is not a singular event but a process and interplay
among several interactive cognitive and affective elements. This is evident by the variety of
associated characteristics that Ms. Scarlet outlined which all interplay to allow for creativity to
be expressed in science. Further evidence of how Ms. Scarlet perceives science creativity is
through the examples of student creativity she shared during the interviews. Ms. Scarlet
emphasized on coming up with experimental design to prove a point or explain something in her
definition of science creativity and when asked if she recalled any example of student creativity
in her science classes, she highlighted that she had:
a couple students where you ask them to come up with procedures and their first design is
beautiful and has great controls and everything is just set up well...and they come up with
a brilliant way to do it and they prove it and you have no doubt whatsoever that this is
proved...and there’s a few where you can call on them and they’ll always have a different
idea of ways to explain things.

Ms. Scarlet’s recollection of student creativity in class mirrored how she defined creativity in
science which incorporates elements of inquiry and critical thinking.

Although Mr. Singh alluded to the need for inquiry and critical thinking as a requirement
for creativity, he did not emphasize it as much as Ms. Scarlet. One additional characteristic that
Mr. Singh highlighted is curiosity. This characteristic relates to his definition of creativity
because curiosity is an element that encourages individuals to “extend beyond more than what
you just give them”.

Other characteristic of science creativity that both participants mentioned is the need for
understanding basic scientific knowledge before creativity can get incorporated. Mr. Singh
explained that this knowledge may come from rote memorization, such as nomenclature in
chemistry which he claimed that no one finds creative. Due to the nature of needing to
memorize, science can be misinterpreted by some people as an uncreative subject which is
consistent with the survey results gathered by Schmidt (2010). Because basic knowledge is
necessary in science, Ms. Scarlet claimed that it is a lot harder to express creativity as compared
to the arts where even if you do not understand the medium, a creative thought can be
established. On the contrary, Mr. Singh compared this basic understanding in science to that of
understanding the foundational structures of art which he claimed as being necessary for the
expression of creativity. Therefore, he claimed that whether creativity is expressed in science or
in arts, there is a similar foundational groundwork needed. The difference between the participants’ views may stem from their individual understanding of the arts as science teachers, as Mr. Singh appears to appreciate an artistic element of science creativity from his description and examples of creativity that he draws upon throughout the interview; however, regardless of whether basic knowledge is needed in the arts to express creativity, it is undisputed by the two participants that basic knowledge is needed in science for creativity to be expressed.

Therefore, despite the common belief that science is a creative endeavour by both participants, they each defined science creativity differently, albeit it both being consistent with what the literature has to offer. The implications of how they defined creativity were also evident through the examples of student creativity they shared.

4.2 Teachers Believe that the Majority of Students Lack Creativity in their Science Class

Despite the participants of this study believing that science is a creative endeavour, they perceived that the majority of students lack the same appreciation for science as a creative endeavour. They don’t claim that it is completely absent from their science classrooms, as there were examples of student creativity in science as outlined in the previous section; however, the majority fail to demonstrate creativity in science. The participants explained that students in their science classes are limited from expressing creativity due to certain characteristics of the students.

When asked whether students think science is a creative endeavour, both participants answered no. Mr. Singh claimed that he “feels like the majority of them surprisingly are more boxed in than we would think”. He added that students can appreciate the arts as a creative endeavour, but “it seems like they’re not able to see creativity within math and sciences and the other disciplines which aren’t usually associated with creativity”. This claim by Mr. Singh
reinforces the idea that people generally do not appreciate science as a creative endeavour (Schmidt, 2010). Therefore, it was no surprise that the participants have a similar perception about the majority of students’ creative capacities in science. Because people do not generally associate science with creativity, students may carry this preconceived notion into their science classrooms which influences their attitude into thinking science to be uncreative; thus, as a result of their attitude towards science as an uncreative endeavour, they fail to actively demonstrate science as being creative.

Mr. Singh expressed his frustration when he explained how students fail to seize the opportunity to show creativity in his class even when he tried to encourage his students to stretch outside the box. Especially when students were given an assignment or project which allows for more flexibility, Mr. Singh said his students “look at me with that kind of desperate look to say like ‘just tell me what to do already’...where it’s like ‘I don’t know what, I don’t get it, I don’t, just tell me what it is, just tell me how to do it’.” Ms. Scarlet shared the same issue when trying to encourage students to demonstrate creativity. “They don’t like it. They are used to being spoon fed. Being spoon fed is easier”. This again indicates that teachers feel students rather be explicitly told what to do than to investigate and explore for themselves. Thus, elements of creativity such as exploring their options and solving problems critically are not something science students prefer as reported by teachers.

To fully understand why teachers perceived that the majority of students lack creativity in science, it is important to understand some characteristics that teachers believed limit students’ capability to show creativity in science classes. One characteristic exhibited by students that the teacher participants felt restricts students from expressing creativity is their own fear of failure. When Mr. Singh attempted to encourage students to be creative when choosing a topic for an
assignment, he felt that “it’s like they’re too scared to go into it, or they feel like it’s not what science should be so they end up choosing a topic that sometimes I feel like you’re bored”. This example from Mr. Singh showed that he feels students would rather choose a topic that they are not interested in and complete the criteria set out by the assignment to get a good grade compared to exploring an area with the potential to “stretch beyond the box”. Consequently, Mr. Singh “felt like there was a sense of drudgery almost in completing [the assignment], rather than a real sense of wonder and, well, creativity”. Similarly, Ms. Scarlet explained that “a lot of students are honestly afraid to try because they’re terrified of failure”. This fear of failure associated with students in school is a function of a school system that prioritizes marks, grades, and correct answers. As a result, students are always concerned about their marks since it is the quantifying element that distinguishes a successful student from an unsuccessful one. Students are trained into thinking that ‘doing science’ is all about getting the facts right and arriving at the one correct answer or explanation because these are the criteria that get them the marks on a test, instead of their thinking process and creativity. Therefore, students fail to appreciate the learning process which involves taking risks and learning from failed attempts. To address this issue of fear, Ms. Scarlet attempts to create an inclusive classroom such that students can take risks, guess at an answer and learn from failure.

Although some examples of student creativity were evident in science classes, there is still a lack of consistent creative expression in science classes. In order to understand why students fail to demonstrate creativity consistently in science, it is important to understand the constraints that may limit teachers from teaching for creativity in science.

4.3 Teachers Experience More Constraints than Supports in Teaching for Creativity in the Science Classroom
Both participants reported more constraints that limit their capacity to teach for creativity in the science classroom than supports which enhance this capacity. The restrictions that were mentioned are related to the resources available for the teachers, to school administration, and to students’ preparation to demonstrate science creativity. Some resources that participants mentioned as a limitation include time, school equipment, and textbooks. These limitations are consistent with what Kampylis et al. (2009) reported as factors that limit a teacher’s ability to foster creativity in his study on perspective and in-service teachers about science creativity.

Nicholl and McLellan (2008) found that time is a major constraint as there is not enough time to cover specific content at the secondary level in order to engage in creative activities. The two teacher participant in this study also found time as a major limitation. Mr. Singh mentioned that he does not always include activities that foster creativity because he does not have time. Ms. Scarlet shared the same concern when she shared that “I find one of the things in science is that I didn’t have time for these giant open inquiry projects to foster huge problem solving epic adventures, because you have no time, there’s way too much curriculum to cover. Way too much!” She understood the importance of curriculum and content learning; therefore, she did not advocate for reducing the amount of curriculum content to do more inquiry or problem solving because students going into first year university need to understand concepts in order to be successful. However, she also mentioned that critical thinking, problem solving skills and creativity are also needed in the classroom as it is an important element of science. The problem she claimed is that teachers spend way too much time on content and not enough time on skills. As a result, she suggested that there needs to be a better balance. She pushed for a better balance and doing more critical thinking and skills in class which requires students to take more responsibility for learning content outside of class, which she does not always count on. She
mentioned that in order for her to feel comfortable emphasizing skills teaching, it must come from the top down “like it needs to come from the government, it needs to come from the school board, it needs to come down to the teachers, that this is sort of okayed by the higher ups that this is what we should be doing.” At the same time, Ms. Scarlet was also hesitant after she made this suggestion because that meant she is not teaching as much content which she felt is also necessary; thus, she summed up her dilemma as a “lovely catch twenty-two”.

In addition to time, Mr. Singh added that sometimes he cannot incorporate certain creative activities into his class or demonstrate experiments because his school does not have the resources. He described that resource for science at his school was “sparse”, which limits how many science experiments he can expose students to. Moreover, another resource limitation Mr. Singh highlighted was the textbooks that are available at his school, which are the same set of science textbooks he used when he was in high school over 10 years ago. Since the body of knowledge in science is meant to be a dynamic process (Schmidt, 2010), the idea that a set of textbook is presenting information that is at least over a decade old does not promote to students this idea about the nature of science. A lack of understanding about what the true nature of science is acts to limit students from extending their content knowledge in science which is needed for science creativity. However, Ms. Scarlet did not mention about textbook or lab equipment as a limitation, these factors may be school-dependent, which is consistent with the claims that Mr. Singh mentioned about the lack of school administrative support he feels for the academics department. He described that he does not feel the level of support from the school in terms of academic creativity especially in science. One specific example of the limited support he receives from the school that he brought up during the interview is the difficulty of bringing his class on a field trip such as going to the Ontario Science Centre. He felt discouraged from
taking his class on field trips due to the administrative hurdles and the logistics of commuting via
the Toronto Transit Commission to the Ontario Science Centre as an example. Moreover, he
also mentioned that there was not any professional development in school that covered the topic
of science creativity. As a result, he did not appreciate the lack of support from the school
administration to support his development in understanding the topic of science creativity. Ms.
Scarlet also shared similar comments as Mr. Singh with regards to feeling that the school does
not place enough emphasis on developing creative thinking. This finding is addressed by
Manning, Glackin and Dillon (2009) who mentioned that more training is necessary in order for
teachers to optimally foster creativity.

One resource that both Mr. Singh and Ms. Scarlet valued in terms of developing their
understanding of science creativity was the Science Teachers Association of Ontario (STAO).
However, once again, due to administrative restrictions, Mr. Singh is limited from participating
fully in the annual STAO conference which is held during the school year. Since STAO is run
by science teachers, Ms. Scarlet found that the professional development at the conference are
generally more practical compared to the professional developments that are run by the school
boards or by faculties of education. Therefore, she appreciates STAO because it offers “practical
professional development of how to include this stuff while still managing to meet [her] other
obligations”. As a result, she explained that although theoretical professional development is
good, there needs to be a larger focus in faculties of education as well as professional
development for already existing teachers about how to practically implement large inquiry
projects. She made this emphasis on engaging in large inquiry project because based on her
definition of creativity, she incorporated inquiry as a characteristic of creativity that is required
in science.
Paradoxically, Ms. Scarlet described the last constraint that limits her from fostering student creativity is herself and other teachers ill-preparing students with necessary tools and experience to demonstrate creativity in science. Ms. Scarlet described that:

a lot of teachers teach [science] in a very uncreative way...The way science is taught...it does not seem to be a creative endeavour. So it is entirely our fault as teachers because when we teach the facts determined by science and when we do labs that give students procedures...there is no creativity in science at all, like zero, ‘cause it’s following a recipe, and there’s a bit of creativity in analysis, but even then, we give students questions to guide their analysis.

Moreover, because creativity is harder to teach, harder to model, and harder to assess compared to content knowledge, teachers end up teaching and assessing more for content. This concern is similarly reported in Kampylis et al. (2009) which claimed that more than 50% of prospective teachers and in-service teachers felt that they are not well-trained enough to act as facilitators of students’ creativity. Therefore, students have limited experience witnessing and demonstrating creativity in science. This lack of experience and practice demonstrating creativity leads to the fear experienced by students that was mentioned in the previous theme in this chapter. However, this is not necessarily at the fault of the teachers because Ms. Scarlet pointed out that teaching experience is necessary in order to gain an insight to the content of the curriculum and the pitfalls of the students before lesson plans can be improved to include elements of creativity. In addition, because there is limited professional development to support teachers in incorporating creativity in science classes, teachers may feel uncomfortable doing so, which is consistent with Turner’s (2013) report that some teachers lack confidence in facilitating creativity. Ms. Scarlet identified that the biggest problem with the issue of science creativity lacking in education is:
me and [the students]...the students are uncomfortable with it, but so are the teachers, and
the only way to make the students comfortable with it is to force them to do it more, but
the only way to do that is to force the teachers to be comfortable with it.

Therefore, Ms. Scarlet agrees with Turner that teachers lack confidence in facilitating creativity.
She feels that more professional development for science creativity is needed for teachers to be
comfortable with teaching towards the skills necessary for facilitating creativity. Small steps of
incorporating science creativity in the classroom using different strategies can also be used to
develop comfort in this area, and some of these pedagogical strategies suggested by the
participants will be highlighted in the next section.

4.4 Teachers Attempt to Foster Science Creativity in the Classroom Using Different
Strategies

In this section, I outline different strategies that participants employed in order to foster
science creativity in the classroom and encourage their students to appreciate science as a
creative endeavour. The teachers aimed to foster science creativity through their pedagogical
teaching instructions and from assignments and activities that encourage student creativity.

The first pedagogical strategy that both participants mentioned in their interview is the
use of scaffolding. Both participants described that they guided their students using scaffolded
questions or gave them small points or ideas towards a particular train of thought. Ms. Scarlet
added that gradually, students will have enough practice that the amount of scaffolding required
reduces by the end of the year. Therefore, she scaffolds more with grade 9 and 10 classes that
she teaches compared to the grade 11 and 12 classes. As an example of explorative task and
open investigation, her goal is to be able to provide grade 12 students at the end of the year a lab
with no procedures or discussion questions and ask them to prove something in particular and
analyze the results. Explorative tasks compared to close-ended tasks (Saxon, Treffinger, Young, & Wittig, 2003) and open investigation compared to recipe work (Sallam & Krockover, 1982) are strategies for creative teaching which Ms. Scarlet incorporated into her class. This is again related to her definition of creativity of being able to come up with a way to logically prove a point using the scientific method. Melar (1993) attributes student-oriented learning as more creative than teacher-oriented, and through both participants attempt to guide students through problems and investigations instead of explicitly telling them the answer demonstrates a classroom that includes elements of student-oriented learning.

Another strategy the participants employed includes investigating and discussing the history of scientific discoveries. Mr. Singh said that “looking into the history of how other scientists got where they got it really kind of sets the bar and shows them an example of really throughout history, science, the biggest advances in science were when people decided to be creative.” The example that Ms. Scarlet described during the interview was exploring the history of the atom. Instead of simply providing the class with the information of how each scientist contributed to the discovery of the atom, she linked each scientist’s contribution to technological advancement and explored how improved technology allowed for the contributions that were made. So similar to Mr. Singh, Ms. Scarlet shared that “a lot of...concepts if you link it back to the history of their discovery, it shows that science is a creative endeavour...and there’s a gajillion of them”.

In addition to pedagogical strategies to encourage students to appreciate science as a creative endeavour, the participants also encouraged students to see and demonstrate science creativity primarily from inquiry-based in-class activities and assignments. Inquiry-based assignments and activities are used by the participants to encourage student creativity in science
Decoding the puzzle is an inquiry-type activity that involves putting together pieces of information to paint a full picture of a solution or explanation to a problem. Ms. Scarlet used this type of activity to introduce glycolysis for grade 12 metabolism unit. She provided image of each step of the process and ask students to identify the order of the entire process. She argued that it stimulates problem solving skills and builds confidences for students because it shows them that they are able to piece together a complicated process through logical problem solving.

Mr. Singh used a decoding the puzzle activity before introducing the periodic table of elements in his grade 9 chemistry unit. Tying back to the history of scientific discoveries, Mr. Singh emulated the problem that Mendelev faced when discovering the periodic table of elements. He gave the class a set of “mixed cards with different colours, symbols, and letters, basically representing different kind of properties”. The challenge of this activity is to be able to piece together the different cards in a way that is organized and structured, similar to that of the periodic table of elements. Mr. Singh explained that this activity gave students “a chance to approach it from that kind of inquiry aspect rather than I teach you or lecture you about it first”. These inquiry approaches are consistent with the strategies that literature highlights as creative teaching, such as explorative tasks (Saxon, Treffinger, Young, & Wittig, 2003), project work rather than lecture based (Mackin, 1996), student-oriented (Melar, 1993), and open investigation (Sallam & Krockover, 1982). Ms. Scarlet shared an example of an explorative task and project work that she used in her classroom, which she described as “the idea that you focus your whole unit or concept around solving a problem”. When she was teaching the grade 11 body systems unit in biology, she acted out symptoms of a specific disease, and each day, she would act out a
new symptom. She allowed for students to ask her questions such as medical history and other information that students deemed relevant to diagnosing her disease. Over the course of the unit, she would relate the content knowledge to this problem. This type of problem-based biology, which DeHaan (2008) claims as a creative teaching strategy, provided students with a real-world context which engaged students and allowed students to explore the issue versus the conventional lecture-based lessons and memorization.

Over the course of the interview, the teacher participants described many instances and strategies they employed in an attempt to foster student creativity in science. These strategies were also mentioned in literature as creative teaching and promoted teaching for creativity. Therefore, through the pedagogical teaching instructions and inquiry-based assignment and activity examples that both participants highlighted, it is evident that they value science as a creative endeavour and wish to demonstrate and inspire students to also have the same appreciate for science as a creative endeavour.

4.5 Chapter Conclusion

This chapter highlighted the prominent themes that emerged from my data analysis. The key research findings showed that although each participant understood the concept of creativity in science in a way consistent with literature, they provided different working definitions of science creativity when explicitly prompted to do so. Despite the difference in how each participant defined creativity, the participants agreed that the majority of students lacked creativity in science. Instances of student creativity described by each participant also demonstrated the variance in their definitions of creativity, as they described instances of student creativity that aligned with how they defined science creativity. The next key finding is related to the constraints that teachers described as limiting their potential of fostering creativity in their
science classes such as the available resources, school administration, and students’ preparedness to demonstrate science creativity. However, both teacher participants described STAO as a valuable resource for developing their understanding of creativity in science. Finally, the last key finding I reviewed in this chapter is pedagogical teaching strategies and assignments and activities for fostering science creativity in the class as described by the teacher participants. Interestingly, some strategies that each participant employed to foster student creativity in their science class also resembles aspects of how they defined science creativity.

Overall both science teacher participants appreciate need for teaching student creativity; however, a lack of consistency was noted between how they conceptualized the concept of science creativity. In the following chapter, I will make implications of the lack of consistency between the two participants’ definition among other implications from my research findings, make recommendations through various perspectives of this topic, and suggest areas for further research.
Chapter Five: Conclusion

5.0 Chapter Introduction

In this chapter, I will summarize the key findings and their significance from the collected data; highlight broad and narrow implications based on the findings from this study, suggest recommendations to address the implications that were made, point out to areas of further research on this topic of science creativity in education, and wrap up this research project with final remarks.

5.1 Overview of Key Findings and their Significance

This section highlights the key findings gathered from this study and emphasizes the significance of these findings with respect to the topic of science creativity within the secondary school education context. I will first describe the significance of how the research participants defined the term creativity, next I will highlight how the participants view student creativity within their science class, then mention some key constraints that the participants pointed out as limiting their ability to foster creativity in their science classrooms, and finally I will express the main strategies that the participants employed to promote science creativity within their classrooms.

The key findings from the definitions of science creativity as articulated by the two participants show the inconsistency and variation that teachers may have when asked to define this abstract concept. Mr. Singh’s definition emphasizes on incorporating your own self through freedom of expression and the ability to extend beyond what you are given. Moreover, his definition of creativity includes an element of beauty, and as such, many of his examples of student creativity include an artistic and visual element, such as the example of an interactive display board, and the creation of a video documentary. On the contrary, Mrs. Scarlet defines
science creativity with an emphasis on solving problems through scientific experiments that proves the hypothesis of the question. Based on her definition, the examples she provided of student creativity in science demonstrate an ability to develop an experimental procedure. However, despite the difference in definition articulated by the two participants, both definitions relate to how Hu and Adey (2002) define science creativity, which is concerned with scientific experiments that are dependent on scientific knowledge and skills, and “doing science” requires going beyond existing knowledge and techniques in order to create new understanding. As a result, both teachers show an understanding of science creativity; however, without a unifying working definition of science creativity within ministry documents, teachers will articulate this concept differently, which impacts their pedagogical approach within a classroom when promoting creativity. Kampylis et al. (2009) also explains that the lack of a working definition may result in the lack of teacher motivation towards the realization of creativity in schools.

Consistent with other studies within the research literature on science creativity in education, teachers in my study perceive students to lack an appreciation for science as a creative endeavour and thus often fail to demonstrate creativity (Fryer & Collings, 1991; Diakidoy & Kanari, 1999). Both teacher participants attribute student’s lack of creativity to the fear of failure. They both expressed that students are primarily concerned with getting the right answer and getting the marks instead of exploring and investigating for themselves. As a result, teachers may become discouraged from engaging students in inquiry and problem-based tasks which can be tools for fostering creativity (DeHaan, 2008).

Aside from fear of failure displayed by students, other constraints that teachers mentioned that limit their ability to foster creativity in their science class is lack of time, school equipment, textbooks, and administrative support. Both teachers expressed their struggle to
cover all the content within the curriculum while still being able to develop other necessary skills such as creativity. Their struggles to foster creativity while still covering all the content within the curriculum coincides with what Nicholl and McLellan (2008) found in their study of teachers’ struggles to implementing creativity. Moreover, other constraints experienced by teachers from being able to fully foster creativity is lack of school equipment, textbooks and administrative support; however, the severity of these constraints may be school-dependent, as one teacher experienced these constraints to a greater degree than the other.

Despite constraints that the teacher participants experienced, they both employed various strategies for fostering student creativity. The common strategies they both attempted include the use of scaffolding, describing the history of science, and performing inquiry-based tasks. Both teachers aimed to provide scaffolding for students so that students are encouraged to discover through exploration which is a creative teaching strategy that can foster student creativity as described by Saxon, Treffinger, Young, and Wittig (2003). Inquiry-based tasks are also able to develop creative thinking for students who engage in them as explained by DeHaan (2008). These are some of the strategies that participants described using in their class to foster student creativity in science.

These are some of the key findings that emerged from the data provided by the two teacher participants. Following this section, I describe implications that are drawn for different stakeholders of the educational community and for my professional identity and practice based on these key findings from my study.

5.2 Implications
From the key findings and their significance of this study, some implications for the broad educational community and for my professional identity and practice can be made. In this section of the chapter, I will highlight these implications.

5.2.1 Broad: The educational community. As both teacher participants brought up during the interviews, there is a lack of time given the extensive curriculum requirements to properly foster creative thinking skills among students. The importance of teaching both content and skills are mentioned by Ms. Scarlet from this study; however, both teachers show that there is not enough time to sufficiently teach for both content and skills. As a result, teachers may place greater focus on teaching content, primarily because it is what teachers are more comfortable teaching, and because it is easier to assess. The implication drawn from these findings show that the curriculum may place an over-emphasis on content as opposed to creative skills, which are also necessary for the success for students in a creative economy. In addition, as suggested by Ms. Scarlet, teachers need to be “forced” to be comfortable with teaching for creativity so that they can “force” students to demonstrate more creativity, which suggests that the curriculum may need to be modified to incorporate a greater emphasis on teaching for creativity as a mandate for teachers to actively foster creativity. Therefore, these implications apply primarily to curriculum developers, policy makers and those in position to influence the development of curriculum.

Further implication from these findings for secondary school teachers within a science class is that classroom instructions and activities may need to aim for purposeful teaching for creativity. However, it appears from the interview data, it is possible that not all teachers are comfortable with teaching for creativity, so until teachers become more comfortable with teaching for creativity, lessons with the focus of creative skills may be under represented. If
teachers fail to provide students with such practice, students may continue to demonstrate fear towards demonstrating creativity.

The need for teachers to develop a comfort to teach for creativity leads into another implication for school administrators. It appears from this study that teachers want professional development in fostering science creativity and administrative support for fostering science creativity. Both participants illustrated that administrative staff at their school pose some constraint to fully fostering creativity for students in their science classes. With additional professional development in the area of science creativity, science teachers may feel encouraged and supported in their pursuit to foster creativity. This may also apply to teacher education programs when preparing pre-service teachers to teach science. Pre-service teachers may benefit from learning about science creativity so that when they become certified teachers, they may be prepared to teach for creativity right away.

These are the broad implications that apply to various stakeholder groups within the educational community based on findings from my study. The following subsection will discuss narrow implications for my professional identity and practice as an individual in the field of science education in the intermediate/senior division.

5.2.2 Narrow: My professional identity and practice. My philosophy of teaching prior to embarking on this research project constituted of wanting my students to critically question the knowledge they gain because I wanted them to develop a deeper understanding of the knowledge which is necessary for furthering the body of knowledge in science and develop a sense of scientific literacy so they can independently identify the fallacies of scientific propositions presented by media. However, my teacher participants described that students rather be told what to do and believe rather than exploring and investigating for themselves and
this sheds some light on the difficulties of actualizing my philosophy of teaching. As a result, based on the findings, my goal upon teaching secondary school science is aimed at devaluing the importance of marks and grades within my classroom so that students can be encouraged to explore their interests within science without the fear of repercussion. My philosophy of teaching has also altered as a result of the findings from this study, as I currently believe that the importance of science education is instilling a sense of curiosity for students in science such that they find joy in exploring science, instead of the fear that so often debilitates students from pursuing science. Through this curiosity and exploration, my hope is that students will critically evaluate the knowledge presented to them, such that they can creatively incorporate and extend that knowledge to uncover and explain the unknowns of this world.

Moreover the knowledge gained from this research study allows me to influence the scope of this topic within the educational community. Understanding that not all teachers are comfortable with teaching for creativity, I can act as a mentor for science teachers within the school department I teach at and the educational community more broadly through discussions and sharing at educational conferences. The importance of this topic also needs to be shared with administrative staff and other curriculum leaders within the ministry; therefore, I am encouraged to start the conversation to bring forth the need to address this gap and oversight in the curriculum and the support necessary from administrative staff to motivate science teachers to foster science creativity.

These are the narrow implications that modified my beliefs throughout this research period and the narrow implications that will affect my practice when I become a science teacher in a secondary school. Recommendations will be made in the next section based on the implications that were identified in this section.
5.3 Recommendations

In this section, I suggest some recommendations that stem from the broad implications I highlighted in the previous section. The first recommendation for curriculum developers and policy makers is with regards to modifying the curriculum. This may take a few years before it can be implemented; however, it needs to be suggested so that these stakeholders can consider these suggestions prior to the next iteration of science curriculum being implemented. It was brought to my attention from this study that there appears to be an imbalance between emphasis on content and skills teaching in the science curriculum. As a result, the curriculum should be modified to reflect a better balance between teaching students for content and for skills, including creativity skills. Additionally, even though the word ‘creativity’ is used in ministry documents such as *Growing Success* (2010), or *Achieving Excellence* (2014), there aren’t any working definitions for teachers to perceive this concept concretely; therefore, ministry documents should also include a working definition of the term ‘creativity’. These modifications will provide science teachers, including myself, motivation towards actualizing creativity skills within the science classroom, and provide tangible conceptualization of science creativity which can unify the goals set out by all science teachers to foster science creativity.

Another suggestion is made towards school administration and teacher education programs. As many teachers are not fully comfortable with demonstrating and teaching for creativity, school administration should provide support for science teachers through immediate professional development. School administration should also encourage science teachers to participate in the Science Teachers Association of Ontario Conference which is hosted annually as a way of professional development, such that teachers can be encouraged to learn different pedagogical tools they can use to teach for creativity. Moreover, for pre-service teachers,
teacher education should also play an immediate role in helping to provide concrete conceptualization of science creativity. As a pre-service teacher, the past two years did not provide me with many tools for understanding science creativity aside from this research study; therefore, including science creativity as a topic of discussion in any science-focused course in teacher’s education can vastly help provide awareness of this topic and help teachers perceive a unified understanding and definition of science creativity.

These are some short term and long term recommendations for different stakeholders aimed at addressing the shortcomings of teaching students for science creativity. The next section of this chapter will highlight some areas for further research to address gaps in this topic that my study was not able to address.

5.4 Areas for Further Research

My research study does not address all the areas of the topic of science creativity, and in this section, I will highlight some areas for further research. Due to the ethical protocol limitations of my research study, I was unable to collect any form of data from high school science students on this topic. With additional data from students in combination with the data I collected from Ontario science teachers, it will provide a different perspective of how students perceive and understand the concept of science creativity from their point of view, thus providing knowledge towards how to best teach for science creativity for students. Furthermore, it is also important to study how teaching students for science creativity impacts them in other aspects of their life socially, emotionally, and mentally, including their performance in other courses, whether there will be any improvements towards entering post-secondary institutions and their success in securing a job in this creative economy. Research towards answering these
questions will be able to gauge success of current science programs in school, and track the benefits of teaching students for science creativity.

5.5 Concluding Comments

As most people fail to associate creativity with science, it is often failed to be mentioned or taught in science classrooms. Therefore, it is my goal to spread the awareness for the need to purposefully engage students in creative thinking in science classrooms. This research study has provided me valuable insight and knowledge in this area which I can use in my practice, and this project is an avenue in which I can promote this topic to other teachers. Moreover, when I become a certified teacher, I will continue to engage in discussion with colleagues in order to promote the need to teach for creativity in science classes. It is my hopes that students can gain an appreciation for science as a creative endeavour, such that they will pursue in a field of science, critically assess the current knowledge we hold on science concepts, and further the body of knowledge we know from science.
References


http://dx.doi.org/10.1108/00400910710754435.


Appendices

Appendix A: Letter of Consent for Interview

Date:

Dear ______________________________,

My name is Edmund Leung and I am a student in the Master of Teaching (MT) program at the Ontario Institute for Studies in Education at the University of Toronto (OISE/UT). A component of this degree program involves conducting a small-scale qualitative research study. My research will focus on understanding how science teachers perceive and seek to foster student creativity. I am interested in interviewing teachers who have 5 or more years of experience teaching science or any of the science streams and who report intentionally seeking to foster students’ creativity through their curriculum and instruction. I think that your knowledge and experience will provide insights into this topic.

Your participation in this research will involve one roughly 60 minute interview, which will be audio-recorded and transcribed. I would be grateful if you would allow me to interview you at a place and time convenient for you, outside of school time. The contents of this interview will be used for my research project, which will include a final paper and informal presentations to my classmates. I may also present my research findings via conference presentations and/or through publication. You will be assigned a pseudonym to maintain your anonymity and I will not use your name or any other content that might identify you in my written work, oral presentations, or
publications. This information will remain confidential. Any information that identifies your school or students will also be excluded.

The interview data will be stored on my password-protected computer and the only person who will have access to the research data will be my course instructor. You are free to change your mind about your participation at any time, and to withdraw even after you have consented to participate. You may also choose to decline to answer any specific question during the interview. I will destroy the audio recording after the paper has been presented and/or published, which may take up to a maximum of five years after the data has been collected. There are no known risks to participation.

Please sign this consent form, if you agree to be interviewed. The second copy is for your records. I am very grateful for your participation.

Sincerely,

Edmund Leung
Consent Form

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

I have read the letter provided to me by Edmund Leung and agree to participate in an interview for the purposes described. I agree to have the interview audio-recorded.

Signature: ________________________________________

Name: (printed) ________________________________________

Date: ________________________________
Appendix B: Interview Protocol

Hi, my name is Edmund. Thank you for agreeing to do this interview with me. As you know, this project studies how secondary school teachers perceive and foster creativity in their classrooms. The interview will be around 60 minutes, and it will consist of 5 chunks of questions, beginning with some background information, then some questions about your in-class teaching practices, followed by your beliefs and values on this topic, and next I will ask questions about influencing factors that you may have experienced with regards to this topic, and finally next steps. At the end, I hope to better understand how teachers perceive creativity and what teaching strategy best fosters creativity.

Do you have any questions before we start?

(TAPE ON)

Section A – Background Information

1. What grades and subjects do you normally teach at your school?
2. Can you tell me a bit about your formal training, including where you studied, what you studied, and when you got your degree?
3. How many years have you worked as a teacher? How many years have you been teaching at this school?
4. In addition to your role as a teacher, do you fulfill any other roles in the school, such as coach, counselor, committee member?
5. What motivated you to choose education as your profession?

Section B – In-class teaching practices

6. Could you describe what happens on a typical day in your classroom?
7. In your own words, could you describe what the word “creativity” means to you?
   a. Does “creativity” mean something different to you in a science context?

8. Can you describe an instance or an example of when a student has demonstrated creativity in your science class?
   a. How often do students demonstrate creativity in your science class?

9. Have you had students that stand out because of their creative thinking ability?
   a. Does the creativity of students generally correlate with their marks in the class?

10. Can you give me an example of a time that you explicitly encouraged creative thinking in the classroom? In assessments?
    a. What teaching strategy do you find works best in fostering student creativity?
    b. How often do you encourage creative thinking?

Section C – Beliefs and values

11. Do you believe science is a creative endeavour? Why or Why not?

12. From your experience, do you think students believe science is a creative endeavour?
    a. How were you able to judge?
       i. If no, do you think measures can be taken to allow students to appreciate that science is a creative endeavour?
       ii. If yes, what are these measures?

13. Can developing creative thinking ability in the sciences benefit students in the future for those who continue to pursue the sciences? For those who do not pursue the sciences beyond high school?
a. What can a student gain from developing their creative thinking ability, in particular with regards to the sciences?

14. Do you think your school places enough emphasis on developing creative thinking?
   a. If yes, how does the school promote creative thinking?
   b. If no, how can the school improve to promote creative thinking?

Section D – Influencing factors

15. What resources have supported you in your understanding of creativity and how to foster creativity?
   a. Administration
   b. Professional development
   c. Ministry
   d. Teacher education

16. Have you faced any obstacles or challenges when trying to promote creativity in your teaching?

Section E – Next Steps

17. What advice would you give to a beginning teacher looking to include creativity in their teaching?

18. What goals do you have for your incorporation of teaching students creativity?

This wraps up our interview. Before we end off, I just wanted to thank you for your time and your responses. Do you have any follow-up to any of the responses you’ve provided or any questions for me?