YEAR 8 STUDENTS PERCEPTIONS OF SCIENCE AND SCIENTISTS

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ABSTRACT

The perceptions students have of science and scientists influence their engagement with the subject. These perceptions are formed through exposure to scientific practices at school and outside of school, as well as by how science and scientists are portrayed. Internationally and nationally there is growing concern about the decline in students studying science beyond what is compulsory. Studies have reported that students' ideas about scientists are dominated by stereotypical images and, while the idea of the 'mad male scientist' has changed over time, contemporary images that represent the ways how scientists work are still absent from many students' experiences.

In response to this concern resources have been developed to provide examples of working scientists, one of which is the New Zealand Science Learning Hub website. The use of ICT resources like this one requires technological pedagogical content knowledge, in order for it to provide meaningful learning experiences. Evidence is now needed to ascertain whether or not such resources have much influence on the ways students think about science.

This study sought to explore 38 year eight students' ideas about scientists and to observe any changes that occurred through the watching of online video narratives about scientists. The data collection methods used were drawings, classroom observations and semi-structured interviews.

The results of this study reveal that the students tested were generally positive about learning science at school and had a good understanding of what scientists did. However, students' knowledge was limited to their classroom experiences and students who participated in extra-curricular science activities displayed an advanced understanding. The video intervention showed that students who had limited science experiences showed a shift in their perceptions of science and scientists.

This study suggests that to keep students engaged in science and to improve their attitudes towards science, meaningful intervention needs to occur. Teachers need to invite students' to share their funds of knowledge and their experiences. Using meaningful resources such as those found on the Science Learning Hub website can enhance students' understanding of science and scientists.

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CHAPTER ONE: Introduction

1.0 Introduction

School students' interest in and engagement with science education has been extensively researched within the educational field. While students are still at primary school they are often very interested in engaging in science activities, however this interest appears to decline as they get older. This decline in interest continues into secondary school, where it becomes particularly apparent when the number of students taking the subject drops after it ceases to be compulsory (Lyons, 2006a).

Studies on students' level of engagement in science have shown that students may come to the science classroom with misconceptions about the nature of science. The images they associate with science and what they think scientists do may hinder their understanding of the subject (Tytler, 2002). To help students get a clearer picture of what science entails, it has been argued that they need to be explicitly made aware of its relevance to their everyday lives and that this should happen at an early age. Research conducted over the past years (Tai, Qi Liu, Maltese, & Fan, 2006; Tytler, Osborne, Williams, Tytler, & Clark, 2008) has found that students often make decisions about their future career pathways before the age of 14. Experiences before this age may therefore have an impact on how students perceive science and whether they see themselves participating in it or not (Tytler, et al., 2008; Bolstad & Hipkins, 2009). It has been suggested that students learn about or meet real scientists to get a better picture of the different facets of science. In response to this call specific information communication technology (ICT) resources have been developed and it is now not uncommon for scientists to visit schools in an effort to share their knowledge and experience (Cowie, Jones, & Otrel-Cass, 2010). However, little is known about whether this affects students' existing views about science and scientists.

Hence, this thesis is an investigation into students' perceptions of science and scientists. It aims to discover whether specifically designed ICT learning resources, in particular scientists talking about their work, have any impact on students' opinions of science.

This chapter begins by providing some background information on student engagement in science (1.2). In (1.3) the rationale behind the research and the research questions is explained. The significance of the study is explained in (1.4). Chapter one concludes with an overview of the thesis structure.

1.1 Background to the Study

Lack of student interest in school science is a concern, particularly when it leads to a decline in enrolment in science courses at secondary school level. This trend has been observed internationally—studies have shown students to be increasingly disinterested in science lessons at school (Hodson, 1998; Goodrum, Hackling, & Rennie, 2000; Millar & Osborne, 1998, Tytler et al., 2008; Schreiner & Sjoberg, 2005) as well as in New Zealand (Bolstad & Hipkins, 2009).

Students' understanding of the subject may be impacted when they lack interest in it. The 2006 Programme for International Student Assessment (PISA) study showed that 19.2% of the 15 year olds surveyed across Organisation for Economic Cooperation and Development (OECD) countries demonstrated a low level of science proficiency (Organisation for Economic Co-operation and Development, 2006). This is an important indicator of how many students within these countries will lack the ability as adults to participate fully in a society that requires some decisions to be made using basic science knowledge. In addition, this report highlighted that while the majority of students were reported to be motivated to learn science, only a minority expressed taking a close interest. This is a concern because only students who take a greater interest in the subject will be willing to invest the effort to do well. In a 2007 OECD report New Zealand students were reported as engaging in science to a similar level as their international counterparts, sitting just above the average for the personal value of science in their lives and just below the average for their own personal interest in the subject (Organisation for Economic Co-operation and Development, 2007b).

More concerning is the fact that students' level of interest in science could potentially drop further before the age of 14 (Tytler et al., 2008). It is thought to be important to increase students' interest in science before the age of 14 because science-related career decisions are being made prior to this age (Tytler et al., 2008). Furthermore, students already engaged in science are likely to become more interested as they study further, while students who were previously disengaged may develop an interest in specific science and technology concepts and processes or, more significantly, come to understand the role science plays in their lives now and will continue to do so in the future.

1.2 Rationale for this Study

"The purpose of science is not to analyse or describe but to make useful models of the world. A model is useful if it allows us to get use out of it" (Bono, 1991). This statement suggests that science education needs to arouse curiosity and enthusiasm in the learner, eliciting a desire to investigate and seek answers as to why things exist in the world as it is.

In New Zealand, science education is designed to offer students a broad understanding of science that can be used for problem-solving, making informed decisions, encouraging critical thinking, providing important knowledge for everyday living, driving innovation, communication and helping develop and broaden their understanding of the world. This understanding can be applied to many different areas of their lives (Ministry of Education, 2007, p.1). Students do not have to necessarily be hoping to follow a science-based career path to gain something useful from studying science. Their understanding of science will have long-term benefits in terms of their participation in society.

In New Zealand NEMP (2003 and 2007) studies have provided evidence of a steady decline in student interest in science (Crooks & Flockton, 2004; Crooks, Smith, & Flockton, 2008). The most recent NEMP study highlighted that year four students were more positive about science at school than were year eight students (Crooks et al., 2008). Other New Zealand studies have also observed a general drop in students' engagement in science from year eight onwards (Bolstad & Hipkins, 2009).

When students are disengaged in science they may display little interest for the subject and decide against learning about it before making future career decisions. They may not realise that even if they do not have a science-based career, they may have to make significant science-related decisions in later life. This disengagement has been linked to students' attitudes towards the subject. Positive attitudes towards science have been reported to be associated with an increase in student enjoyment of the subject and a willingness to learn.

Research has also shown that student disengagement is partially a result of students' inability to relate school science to real-life science (Bolstad & Hipkins, 2009). One way of fixing this may be through the use of contextual materials (Bolstad & Hipkins, 2009). Providing students with examples of people engaged in science and technology-related careers is one possible way forward in maintaining student engagement in science and in enabling young people to make informed decisions in the future (Bolstad & Hipkins, 2009). This may also enable them to make links between their existing knowledge, classroom experiences and what they learn later on (Jones, Cowie, & Buntting, 2009). This initiative is now being put into practise within the New Zealand science curriculum (Ministry of Education, 2007).

The Nature of Science strand of the New Zealand curriculum is the overarching strand for science and highlights the need for students to gain a better understanding of what science is and how scientists work (Ministry of Education, 2007, p. 29). It is important for teachers to better understand how this can be achieved successfully within the science classroom through the use of relevant resources.

So, it is clear that timely intervention is needed to engage students in science and to foster positive attitudes towards the subject. The researcher is a secondary science teacher with just over ten years of experience and has been interested in ways to enhance students' engagement in science for some time. This research provided an opportunity to take a closer look at an intervention which aimed to investigate whether contextual examples positively influence how students perceive science and scientists.

This study used a small sample of 12 year old students to find out whether year eight boys' and girls' perceptions of science and scientists is affected by and has any influence on their existing perceptions after they view video narratives about real life scientists and the work they do. To investigate this aim the study posed the questions below.

Research Questions

This research seeks to answer the following questions about students' perceptions of science and scientists:

1. What are year eight boys' and girls' existing perceptions of science and scientists?
2. Will the use of video narratives about a variety of scientists at work influence students' existing perceptions of scientists and science?

1.3 Significance of Study

Student disengagement in science needs to be addressed if we are to equip future generations with sufficient scientific knowledge. According to Hodson (1998) students are disengaged because they do not find school science relevant to their lives. The content presented to them is at times disconnected from their everyday lives. This influences how students feel towards the subject and their lack of positive feelings results in disinterest. For students to be engaged in science and able to relate to the subject it is important that they feel positive about it (Baker & Jones, 2005).

NEMP (2003 and 2007) studies have shown that intermediate students are less positive about science than primary students (Crooks & Flockton, 2004; Crooks et al., 2008). The participants in this study will be year eight students. This particular age group was selected based on what we know about students losing interest in science around the age of 14; the assumption is that any intervention aiming to re-engage them should occur prior to this age.

Studies on the use of context-based materials such as *Salters Advanced Chemistry* (Bennett, Gräsel, Parchmann, & Waddington, 2005) to improve students' attitudes towards science have shown an improvement in students' attitudes towards and enjoyment of science lessons (Bennett, Hogarth, & Lubben, 2003). Context serves as the starting point for developing scientific ideas in context-based materials, according to Bennett et al., (2003). This differs from more traditional approaches that cover scientific ideas first, before looking at applications. For example, one approach could be to introduce concepts relevant to students' everyday lives or focus on the work of scientists (Bennett et al., 2005). A context-based resource has been used for this research. It is hoped that the findings of this study will provide useful information on whether the use of context-based video narratives will have an impact on students' perceptions of science and scientists. Such information could potentially be useful in advising science teachers, careers advisors and curriculum planners in schools, in addition to educational researchers.

1.4 Research Study Brief Overview

This thesis is organised into five chapters. Chapter one has introduced the aim of the study, the background to the research question and an overall synopsis of this thesis. Chapter two will provide a literature review relevant to the study. It will discuss students' attitudes towards science, factors influencing this and how students' attitudes towards the subject can be improved. A student's science identity will play an important role in influencing their attitude towards science; the factors influencing these attitudes will also be discussed. The review will further explain the significance of pedagogical content knowledge (PCK) and technological pedagogical content knowledge (TPCK). This will provide useful information to classroom teachers intending to use ICT resources for their content delivery. Lastly, there will be a discussion on the use of videos for providing contextual examples, focusing specifically on what the current literature has reported. Chapter three will describe the research methodology and methods used in this study for data collection. It will describe the theoretical framework that has been used to guide this study. Chapter four will present the data collected and the results of the analysis. Key themes that emerged from the research questions in this study will be analysed in chapter four. Chapter five will discuss the research findings and attempt to answer the research questions. The limitations of this study will also be discussed. Lastly, the implications of this study on further research will be presented.

CHAPTER TWO: Literature Review

2.0 Introduction

This literature review will focus on declining student attitudes towards school science and the impact of this on students' perceptions of science and scientists in general. Declining student attitudes are influenced by their out of school learning experiences, including influences from family, media, visits to the museum and television. Students' perceptions of science are also influenced by the science they encounter at school, including the content knowledge, teacher expertise, practical work and variety of resources used to impart scientific knowledge, as well as peer influences. Therefore, changing attitudes towards science may require interventions to increase student engagement in science and maintain students' interest in the subject in later years.

The literature review will present research on students' attitudes towards science. It will also examine some of the measures used by other studies to collect data on students' attitudes. It will reflect on the changes in these attitudes during the transition from primary to secondary school, as reported by past studies. These changes in attitude between primary and secondary school are influenced by factors within school, such as the learning experiences provided through classroom teaching, and out of school experiences—these shape the funds of knowledge students bring to the classroom. These experiences become more evident as students enter the science classroom and it becomes clear what they associate with science teachings. This study will further focus on the influence of school practices on students' science images.

Added to these factors is the students' science identity, which plays an important role in influencing their perceptions of science and scientists. This chapter will also highlight the findings of earlier research into students' experiences within school and outside of school and how these shape students' science identity.

The literature review will present the suggestions that have been made regarding students' engagement in science education, with a focus on the use of context-based materials. One such resource used in this study is ICT; this was used to find out if it influences students' perceptions of science and scientists. An understanding of technological pedagogical content knowledge (TPCK) is also necessary for educational practitioners using ICT resources. The chapter will conclude with a summary.

2.1 Student Attitudes towards Science

Students' attitudes towards science have been of great interest to the educational science community for the past few decades. This rise in interest is a result of a general lack of interest in school science among school students. Olsen and Lei (2011) reported that the attitudinal component of science is an important learning outcome in science education, as it supports and maintains the learning process and is an important predictor of career choices in later life.

Studies on students' attitudes towards school science have revealed that students appear to lose interest in the subject as they get older (Breakwell & Beardsell, 1992; Doherty & Dawe, 1988). This has an effect on students' science enrolment in later years. Further studies on students' science attitudes have also shown that their negative feelings lead to a lack of interest in the subject and therefore decreased engagement (Atwater & Wiggins, 1995; Osborne, Simon, & Collins, 2003).

Attitudes can be defined as an outcome of an individual's experiences, which are influenced by the environment in which they are placed and the attitudes and behaviours of people they associate with (Lakshmi & Rao, 2003). According to Osborne et al., (2003), students' attitudes towards science are: "the feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves" (p.1053). Thus, an individual's attitude towards science reflects their personal response towards the subject. It is developed through experiences and has been measured using 'favourableness or unfavourableness' indicators (Lakshmi & Rao, 2003). Favourableness refers to positive feelings for the subject, while unfavourableness encompasses negative feelings a student may have for science.

Positive attitudes towards science have contributed to higher achievement levels in the subject as a result of increased levels of interest and participation (Weinburg, 1995). Students with negative attitudes towards science may display a lack of interest in the subject. Attitudes towards the subject influence engagement with it, thus positive attitudes would result in higher levels of engagement (Osborne et al., 2003). Concerns over these attitudes have increased over the years as student interest in the subject has declined, and with it the pursuit of scientific careers (Osborne et al., 2003).

A recent study conducted by the Programme for Student International Assessment (Organisation for Economic Co-operation and Development, 2006) identified three important reasons why students need to have a positive relationship with science:

i) Continued investment in scientific endeavour relies on broad public support, which is influenced by citizens' responses to science and technology
ii) Scientific and technological advances are important influences on nearly everyone's life
iii) A continued supply of scientific personnel requires a proportion of the population to take a close interest in science (p.26).

Keeping students engaged in science education has a positive ripple effect throughout society. This effect permeates from the individual's understanding about science to society's attitudes towards science globally.

Alternatively, the consequences of disengagement with science are a concern both internationally and in New Zealand. Hodson (1998), Goodrum, Hackling and Rennie (2001) and Millar and Osborne (1998) are among those who argue that students are increasingly disengaged with science lessons at school because of their poor attitudes towards the subject. This decline is thought to start as early as primary school (Osborne et al., 2003). While it is understood that attitudes towards science are significant and are related to students' engagement with the subject, they remain subjective in nature. This makes them difficult to measure.

Studies conducted over the years have used a number of different measures to gain an insight into students' attitudes towards science. These will be discussed in the next section.

2.1.1 Measuring Students' Attitudes towards Science

Attitudes are formed by a number of sub constructs which contribute in varying ways towards students' attitudes towards science. These sub constructs have been used in various studies to measure students' attitudes towards science. Studies conducted over the last few decades by Breakwell and Beardsell (1992), Brown (1976), Crawley and Black (1992), Gardner (1975), Haladyna, Olsen, and Shaughnessy (1982), Keys (1987), Koballa Jr. (1995), Oliver and Simpson (1988), Ormerod and Duckworth (1975), Piburn (1993), Talton and Simpson (1985, 1986, 1987), and Woolnough 1994 (as cited in Osborne et al., 2003) have used a variety of measures to gain a better picture of the factors influencing attitudes towards science. These include anxiety toward science; views on the value of science; self-esteem in regards to science; motivation towards science; enjoyment of science; attitudes of peers and friends towards science; attitudes of parents towards science; the nature of the classroom environment; achievement in science; the perception of the science teacher and fear of failure. When measuring students' attitudes towards science, caution needs be taken as the measures taken are those of students' feelings towards the subject which are subjective. When trying to understand students' attitudes researchers should therefore not only focus on constructs, but also include students' attitudes towards school science and their attitudes towards pursuing science courses at school in later years. This broadened focus will help provide enriched information regarding students' subject choices (Osborne et al., 2003).

International comparative studies have provided policy makers globally with useful information on students' attitudes to science. For example, PISA studies have assessed the knowledge and skills of 15 year olds. This age group was chosen because it represents the end of compulsory schooling for most OECD countries. PISA assesses students' knowledge, skills and attitudes in relation to science since 2000 and has been repeated every three years. In 2006, the study included 30 OECD member countries and a similar number of non-member countries across the world. The PISA study assesses students' scientific literacy and in 2006 an additional attitudinal component was added to its scope. PISA measures scientific literacy as a way to understand an 'individual's... willingness to engage in science related issues and with the ideas of science' (Organisation for

Economic Co-operation and Development, 2006a, p.12). The 2006 PISA study measured students' attitudes towards science using a questionnaire that looked at students' general and personal value of science, their interest and enjoyment of science, their perception of their own scientific abilities and whether or not they were motivated to use science in the future. PISA (2006) described student attitudes by acknowledging the context—who students were at that point in time—whilst evaluating their engagement in science activities (Organisation for Economic Co-operation and Development, 2006).

New Zealand participated in PISA and also conducts the National Education Monitoring project (NEMP), which provides information on educational achievements and attitudes. Samples of students are assessed at year 4 (half way through primary education) and year 8 (at the end of primary education). The NEMP studies (2003, 2007) have used surveys to gain an insight into year 4 students' attitudes as they impact their progress and learning outcomes in science (Crooks & Flockton, 2004; Crooks et al., 2008). The key focus here has been gaining an understanding of how students regard science in relation to themselves and their ideas of how capable they are and what they could be doing in science now and in the future. Students were asked about their curriculum preferences, their understanding of their own achievement and potential in science and their participation in science related activities within and outside of school. Findings from NEMP (2007) have been used in relation to this study. These will be discussed further in chapter four.

2.1.2 Changes in students' science attitudes from primary to secondary school

The Trends in International Mathematics and Science Study (TIMSS) in 2007 reported that the development of positive attitudes towards science in students is an important goal of the science curriculum in many countries (Mullis, Martin, & Foy, 2007). Research that began in the early eighties reports that interest in science often drops when students enter secondary school (Kahle & Lakes, 1983). International surveys have shown students to be disengaged in science lessons at school (Goodrum, Hackling, & Rennie, 2001; Hodson, 1998; Millar & Osborne, 1998). This trend has not changed much, as is demonstrated in international surveys like TIMSS (2007). This showed that students in year 4 were generally more positive about learning science than students in year 8. The TIMSS (2007) study also suggested, however, that students' ability to do well in the subject is more based on their prior learning experiences, the difficulty of the subject content and the child's ability to learn than on whether they like science or not. In this study boys and girls had similar attitudes towards learning science in year 4. Differences were observed in year 8 students, when boys showed higher self-confidence compared to girls (Mullis, et al., 2007).

The 2006 PISA study reported some encouraging findings on students' attitudes towards science. The majority of the students surveyed (92%) thought science was important in understanding the natural world, although only 57% found science to be relevant to them personally. The survey also showed that 72% of the students recognised the importance of doing well in science and 67% students viewed science as a means of acquiring new knowledge. Although students expressed an interest in learning science, only a minority wanted to pursue science as a career. Slightly more than half of the sampled students viewed science being useful for further studies (56%), while only 37% said they would like to work in a career involving science. Pursuing advanced science at university was important to only 21% of the students (Organisation for Economic Co-operation and Development, 2006). This indicates that although students demonstrated a motivation to learn science at school and an understanding of its importance, there is a lack of willingness to pursue the subject in later life.

New Zealand was ranked one of the higher-performing OECD countries in terms of students' performance in science and self-efficacy for science. Gender differences in attitudes were not found to be prominent in New Zealand. These reports are encouraging from an international perspective. However, studies carried out in New Zealand also reported changes in students' attitudes towards science as they moved from primary to high school.

The 2003 and 2007 NEMP studies showed a significant decline in students' attitudes between years 4 and 8 (Crooks & Flockton, 2004; Crooks et al., 2008). The NEMP study conducted in New Zealand in 2003 reported that 62% of year 4 students demonstrated positive attitudes towards doing science at school while only 32% of year 8 students were reported to have a positive attitude towards the subject in the same year (Crooks & Flockton, 2004). The NEMP study conducted four years later (2007) in New Zealand showed a smaller difference between years four and eight. This study reported a slight increase in year four students' attitudes towards school science (64%) but a significant decline for year eight students—only 24% indicated that they enjoyed science at school. Although students in year four were generally positive about doing science at school, they were at the same time generally concerned about the lack of science learning opportunities provided at school (Crooks et al., 2008). The reports of the increasing dislike of science among year 8 students caused great concern. In line with international trends, New Zealand studies have observed a general drop in students' engagement in science beyond years eight and nine (Bolstad & Hipkins, 2009).

Students' attitudes are influenced by their personal opinions of the subject, which have in turn been influenced by factors within their learning environments—one of which is school. The next section will discuss the factors influencing students' attitudes towards science.

2.2 Factors Influencing Students Attitudes towards Science

Students' attitudes towards science have been a topic of interest in educational research for some time. This has resulted in an increased amount of knowledge on students' perceptions of the subject being made available to researchers and practitioners. Attitudes towards science are reported to be influenced by factors such as parental and family influences and students' self concept, locus of control, achievement motivation, attitudes' towards subject matter, classroom environment and teachers (Atwater & Wiggins, 1995). Gender, personality, structural variables (support of family, peers and friends) and curriculum variables are also thought to influence students' attitudes towards science (Osborne et al., 2003). In addition, school-related experiences that involve the classroom environment, the science curriculum, teachers and self-related variables seem to play an important role. When these factors influence students' attitudes positively, this impacts on their level of engagement and learning at school (Zacharia & Barton, 2003).

Early studies (e.g. Schibeci, 1984; Weinburg, 1995) on students' attitudes towards science observed that gender played a significant role in shaping student views. Research in the eighties showed that girls were often less positive towards science than boys. This was frequently reflected in their apparent lack of interest in and engagement with the subject (Osborne et al., 2003). However, this appears to have changed with time and recently girls have been observed to be more positive about science than boys (Osborne et al., 2003). Girls have displayed an increasing interest in subjects such as mathematics, science and technology, all of which were considered ‘masculine’ in the past. These findings contradict earlier suggestions and that gender itself may now only contribute a minor part in the attribution of success (Osborne et al., 2003).

The decline in gender-stereotypic views of science over the years has been reflected in girls’ increasing enrolments in and success at high school science (Parker & Rennie, 2002). Recently, Parker and Rennie (2002) argued that girls believed in their scientific abilities more than boys. However, the 2003 and 2006 PISA reports did not observe any marked gender differences in science performance for students; whatever differences existed were small (Organisation for Economic Co-operation and Development, 2003; 2006).

Completely disregarding these differences is not possible however, it is these differences in attitude that determine if students choose a career in science later on in their life. Gender differences can also vary between countries; in some countries boys and girls displayed similar attitudes and levels of performance, while other countries such as Germany, Iceland, Japan, Korea, the Netherlands, the United Kingdom, Chinese Taipei, Hong Kong-China and Macao-China reported significant gender differences. Boys in these countries were reported to have a more positive attitude towards science than girls (Organisation for Economic Co-operation and Development, 2006).

The 2006 PISA study reported that some of the precursors to student engagement are a positive learning environment, an understanding of how science provides a better understanding of the world and a feeling that science is personally relevant (Organisation for Economic Co-operation and Development, 2006).

At school students’ engagement with learning is associated with positive attitudes and this is reflected in their class participation (Ministry of Education, 2009). Fensham (2006) reported that declining levels of student interest in science may be the result of the traditional nature of the science curriculum and its lack of relevance to students.

In New Zealand, the 2007 NEMP study (Crooks et al., 2008) suggested that some of the factors influencing students' lack of interest in school science were the school science programmes, the decline in science activities that students find stimulating and increased demands from other curriculum areas.

In addition to these factors, students' science identities further shape their attitudes towards the subject. This will be explored next.

2.3 Students' Science Identity

Student perceptions of science are influenced by their experiences both in school and outside of school and these shape a student's science identity. Generally, science identity refers to "who we think we must be to engage in science" (Barton, 1998, p. 379). This influences students' conscious or subconscious decisions to engage or disengage in the science classroom. Understanding science identity is important for researchers and classroom practitioners as they work towards improving students' attitudes towards science and increasing engagement in the science classroom.

Science identity is not a single trait but rather consists of a range of ideas, beliefs and experiences that shape how a person views themselves in relation to science (Tucker-Raymond, Varelas, Pappas, Korzh, & Wentland, 2006). The general definition of identity has been conceptualised and used in different ways by researchers. For example, some researchers (e.g. Brickhouse, Lowery, & Schultz, 2000) have focussed on social and personal identities, while others have placed emphasis on the particular identity or part of identity that students develop in the science classroom (e.g. Brown, 2004 as cited in Shanahan, 2009). Social and personal identities are those that students hold outside the science classroom and involve race, gender, class and family relationships. Particular identities or parts of identities are those that are influenced by classroom factors such as teaching material, style, teacher influence, student dynamics, etc. These identities cannot be discussed on their own but rather must be viewed in the context of the interplay between the individuals and their surroundings and relationships they form (Roth & Tobin, 2007).

Identities do not exist on their own or in the minds of individuals. They also do not occur spontaneously but rather are built up over time and are influenced by many contributing factors, such as the experiences they encounter in this world and their personal responses to these experiences. Identities exist as co-constructions that cannot be treated separately from individuals, their surroundings and relationships. Therefore, students do not construct identities on their own and are both constrained and guided by the possible identities that are available in their social situation (Shanahan, 2009).

Schools are dynamic social environments for students and their identities can be shaped and reshaped depending on the experiences gained in this environment (Roth & Tobin, 2007). Students need to be able to see science as relevant to the identities they are building to remain engaged in science. Therefore, the experiences students have in regards to science learning become important because they contribute to shaping students science identity, which in turn is a key factor in influencing attitudes towards science (Tucker-Raymond et al., 2006). In addition, identities are not determined by ethnicity, gender or the social class one is born into but these factors play a part in the co-construction of individuals' identities (Roth & Tobin, 2007).

2.4 Identity Formation

Science identities are also influenced by the science we are exposed to in our surroundings. Although we can choose to like or dislike science as a subject, there are aspects of science identities that are within us without us being aware of it. Identity is a quality that is not fixed and stable but may vary with place and time (Roth & Tobin, 2007).

Roth and Tobin (2007) explain the identities we form through their agency/passivity "dialectical relationship" (p. 341) whereby the theoretical thinking about the agential nature of identity has come from work conducted in the social sciences, including science education. Agency refers to the ability of an individual to shape the world around them. It refers to how individuals construct identity rather than act it out (Shanahan, 2009). For example, agency can be observed in students' classroom discussions when students situate themselves and the topic on hand in relation to who they are, who they want to be or by adopting new roles in group dialogue. Therefore identity may be generated as a by-product through class discussion or as the main topic. Passivity refers to the social interactions occurring at the macro-, meso- and micro-levels of participation, as an individual's actions reflect who they think they are. It is through an individual's experiences that their interactions are shaped. Therefore science identity is shaped by what we do intentionally and what is done to us (Roth & Tobin, 2007). This understanding of science identity helps inform science educators with regards to the teaching content and resources to use to increase student engagement.

Identity formation plays an important role in students' science engagement (Barton, Tan, & Rivet, 2008). Some of this is evident in students' attitudes towards the subject, where students with positive attitudes show increased engagement. When teachers understand their students' science identity they can gain better insights to the images students have of science that have helped shape these identities. Teachers can then influence their attitudes towards the subject. These images help build a student's science identity, which is crucial to whether or not students see themselves as potential 'scientists'.

2.5 Influence of school science practices on students' images of science

The images students have of science and scientists typically represent their thoughts and understandings of the subject. These images reflect students' perceptions and can affect their attitudes towards science (Scherz & Oren, 2006). Images of science can be more or less stable and can correspond to students' experiences with scientific practices within or outside of school (Ryder et al., 1999, as cited in van Eijck, Hsu, & Roth., 2008).

Scientific practice refers to student participation in science labs, science classes or during out of school experiences and can include using resources such as movies and videos or visiting museums (van Eijck et al., 2008). The knowledge gained through these experiences can vary depending on student accessibility to such resources.

Students' images of science are not stable entities. Recent studies have reconceptualised these images as particular co-productions at a given point in time (van Eijck et al., 2008). This definition links scientific practices (within and outside of school) and images of science as produced by students—in other words, the process by which students imagify science. The 'imagification' of scientific practice (van Eijck et al. 2008, p.618) describes how the science practices students have engaged in influence their perceptions of other contexts.

This involves observing other scientific practices and translating them according to personal understanding. Therefore, the images produced are co-productions of scientific practice that have been translated and acquire a new meaning as they progress from one activity system to the next. These co-productions are no longer identical to the original scientific practice (van Eijck et al., 2008). During this process, students' ability or inability to comprehend these practices may influence the images portrayed.

However, it should also be noted that students' experiences with scientific practices may be limited at times to school-like contexts such as science labs, textbooks, teacher knowledge, etc. In such contexts, particular co-produced translations of scientific practice become even more significant because they add to a layer of pre-existing "images of science" (van Eijck et al., 2008, p. 631). Students' with limited science experiences hold to images of science environments that are unreal and not necessarily positive; in some instances they are oversimplified images that reflect what has been observed through media such as television (Scherz & Oren, 2006). In Scherz & Oren's study (2006) students were asked to complete two drawings. The first picture they were required to draw was of a technological workplace and the second was of a scientific workplace. The students' drawings depicted dangerous and threatening environments, often linked to those seen on television programmes that show (fictional and non-fictional) scientists at work. The students in this study lacked a realistic understanding of the work of science professionals and used stereotypical features in their drawings. Scientists were frequently drawn as middle-aged males wearing glasses and a lab coat with bald or unkempt hair.

Since students' images of science are contextually bound, the extent to which these contexts determine students' images of science is unclear—especially since transfer of knowledge from one context to another cannot be taken for granted (Brown, Collins, & Duguid, 1989). For example, students' observations of scientific phenomenon in one context and subsequent inferences may not necessarily translate to another context. This is dependent on students' interpretation of the context.

Problems arise when the methods used to determine the influence of contexts on students' images of science differ between studies. This results in varied interpretations of student's images of science (van Eijck et al., 2008). For example, students may draw upon different epistemologies in different contexts when they respond to surveys gathering information on images of science (Roth & Tobin, 2007). Contexts exist as a collection of human activity and students make entities that may not be identical to each other available to researchers. This reflects the 'less stable and individual nature' of students' images of science (Roth & Tobin, 2007, p.2). Further complications arise when researchers' understandings of students' images of science appear to be imagified in and of themselves—that is, when researchers interpretations of what students' images of science should be are reported based on the researchers' personal opinions. Regardless of these drawbacks, it is useful to examine how students' images of science arise and what contributes to the meanings students make of scientists.

Students gain ideas and knowledge about science and scientists from the experiences they have at school and at home and from the information that is shared in their communities. These have been described as 'funds of knowledge' and will be discussed in the following section.

2.6 Funds of Knowledge

The term 'funds of knowledge' has been described as knowledge that is "historically accumulated and culturally developed" (Moll, Amanti, Neff, & Gonzalez, 1992, p. 133). It refers to an understanding that is accumulated over time and influences the way we interact with our world and the people in our lives and how individuals engage in their communities (González, Moll, & Amanti, 2005).

Students accumulate funds of knowledge through their participation in activities with people—and in places—outside school. These can be diverse and abundant (Ellinwood, 2009). Understanding this kind of knowledge and inviting it into the classroom enables science teachers to address conflicts in conceptual understanding, engender a positive and engaging learning environment and, more importantly, make meaningful connections with students' prior knowledge. Incorporating these funds of knowledge into classroom teaching enables students to make use of their prior knowledge and make links between the scientific concepts they encounter in their daily lives and what they learn at school (Ellinwood, 2009).

Rather than discounting this information, by acknowledging it teachers validate the information students bring to the classroom and enhance student engagement. This creates a firm foundation for future learning (Upadhyay, 2006). This approach attaches value to students' prior knowledge and uses student diversity to increase student engagement and success (Hattam, Lucas, Prosser, & Sellar, 2007). It also helps teachers to provide students with meaningful experiences that will contribute to building their science identities and may motivate them to study science in the future (Cowie et al., 2010).

Addressing students' funds of knowledge enables them to gain an understanding of science and its relevance to their lives (Cowie et al., 2010) and therefore make meaningful connections. Students are also then able to help other students make similar connections or question scientific concepts (Ellinwood, 2009). The role of the teacher in this process is important—they ensure that students' existing knowledge is used as a foundation for fruitful classroom experiences and to help foster positive attitudes (Ellinwood, 2009). With this information at hand, teachers will also need to have an understanding of how to use it effectively to influence students' attitudes towards science. This will be discussed in the next section.

2.7 Changing Students' Attitudes to Science

Having gained insight into students' images of science, their science identity and their funds of knowledge, attention needs to shift towards ways of changing students' attitudes towards science and enhancing their enagagement with the subject.

There is compelling evidence suggesting the age at which student interest in science maybe lost. To create interest in science it is important to foster positive attitudes from an early age. Studies have suggested that although the decline in student interest in science is not linear, it may accelerate rapidly from age 14 onwards (Osborne et al., 2003; Tytler et al., 2008).

Influencing students' attitudes towards science before the age of 14 is important because learning in later years is dependent on these early foundations (Bolstad & Hipkins, 2009). Attitudes prior to this age also contributes to career decisions later on (Organisation for Economic Co-operation and Development, 2006). Prior to this age, it is important to enhance students' interest in science by providing meaningful interventions (Osborne et al., 2003) especially since students' attitudes have been linked to their prior attitudes and the degree of success they have experienced a learners (Tytler et al., 2008).

Lyons' (2006a) meta-analysis of three studies (Lyons, 2006a; Lindahl, 2003b; Osborne & Collins, 2001) highlighted three major reasons why students were losing interest in science. To begin with, they disapproved of the lack of personal opinion and expression allowed in science due to the transmissive nature of science curriculum. They also found the science curriculum to be decontextualised and disengaging, which made the content boring and difficult to understand. Kearney and Treagust (2001) also suggested that student interest in science is lost because the content lacks challenges and seems irrelevant to students. Lack of engagement may also occur because the teacher is unable to adequaltely unpack the learning content at an appropriate level (Cowie, Moreland, Jones, & Otrel-Cass, 2008).

To be interested in the subject, students need to be able to relate to the subject content and find some commonality with their everyday lives. They should also be able to gain a realistic understanding of the subject, the work related to this field and its associated professionals (Scherz & Oren, 2006). Traditional teaching methods often do not permit much of this, especially if the teaching style is that of a lecture or if only the recollection of facts and ideas is encouraged (Moore, 1989). A contextualised science education may enable students to understand the relevance of the subject to their daily lives. Teaching strategies should also consider providing students with examples of people who work in science and technology fields (Bolstad & Hipkins, 2009). Bolstad and Hipkins' (2009) latter suggestion provides the focus of this study, which explores how this influences students' perceptions of science as a subject.

However, for this to happen teachers will need to be equipped with the knowledge and skills to identify appropriate approaches that reflect the challenges inherent to science contents and contexts. It is also important for teachers to select appropriate resources in support of this. The next section discusses pedagogical content knowledge to explain the different forms of understanding a classroom teacher can draw on.

2.8 Pedagogical Content Knowledge (PCK)

Teaching is a highly complex process and requires teachers to draw on different forms of understanding—including what they know about their students' ideas about a particular concept and what they know about pedagogy relevant to that content. All of this is shaped by a teacher's subject matter knowledge (Mishra & Koehler, 2006). Additionally, teachers need to manage the resources that are available to them.

The accumulation and growth of content knowledge in the minds of teachers is complex and difficult to understand. Shulman (1986) argued that teachers' subject content knowledge and pedagogy were treated as mutually exclusive domains, which created teacher education programmes that predominantly focussed on one or the other. Teachers mastered skills in either pedagogy or subject content knowledge, not both. To address this Shulman proposed pedagogical content knowledge (PCK), which incorporates the relationship between the two (Mishra & Koehler, 2006).

PCK consists of three types of knowledge, as suggested by Shulman (1986): (a) subject matter content knowledge, (b) pedagogical content knowledge, and (c) curricular knowledge. Generally, content knowledge refers to the amount and organisation of knowledge in the minds of the teacher, which is represented by Bloom's cognitive taxonomy, Gagne's varieties of learning, etc. (Shulman, 1986). Subject matter content knowledge differs between subjects and requires an understanding of how different content is structured around basic principles and validity of truths. Pedagogical content knowledge (PCK) on the other hand takes into account the idea of teacher knowledge—this goes beyond subject content knowledge and incorporates teachers' own experience and study of the subject matter. Therefore, PCK addresses matters of content and pedagogy mutually. Curricular knowledge is the knowledge of educational tools that can be used to effectively present subject content knowledge (Shulman, 1986).

At the core of PCK is how the teacher transforms subject matter and organises, represents and adapts it to meet the diverse interests of learners (Mishra &

Koehler, 2006). It includes an understanding of the conceptions and pre-conceptions that students bring to class, use of appropriate teaching strategies to reorganise any misconceptions and knowledge of the subject to be taught (Shulman, 1986). For example, history as a subject should not be taught by re-telling history, but rather should be delivered to students in a way that includes the teaching of general and specific subject knowledge and skills as well as the development of the student as a citizen; it should explain how this knowledge is made relevant to their lives (Bolick, Hicks, Lee, Molebash, & Doolittle, 2004). Therefore PCK is a 'topic specific and context-specific kind of knowledge and that teachers use to develop PCK in response to their experiences as teachers' (McCrory, 2008, p.194).

Educational institutions now have an ever increasing range of tools to draw their best practice from. One such source is ICT, with a wide range of technology being made available in schools today for teacher and student use. Despite its availability, an appropriate understanding of how to use these tools is necessary (Zhao, 2003, as cited in Mishra & Koehler, 2006). If used ineffectively, useful tools will fail to enhance students' knowledge.

The availability of ICT in society today has provided educational practitioners with a vast amount of resources to choose from: keeping up with this information technology is important due to its constant, rapid advancements. Use of technology in schools requires thinking beyond PCK. It is important that there be a rich connection between the technologies used, the subject-matter (content) taught and how it is taught (pedagogy) (Koehler, Mishra, & Yahaya, 2007). For example, to keep students engaged in science Bolstad and Hipkins (2009) suggested making science relevant to students by engaging them with science professionals. This involves inviting scientists into the science classroom, which may not always be feasible. Therefore, being able to use readily available ICT resources and understand how to integrate this within classroom teaching is important. This is best explained using the emergence of technological pedagogical content knowledge. This will be discussed in the next section.

2.9 Technological Pedagogical Content Knowledge (TPCK)

Shulmans' (1986) idea of pedagogical content knowledge has been suggested to be extended into the domain of technology. With the introduction of technology, PCK should be regarded as one component of a broader framework called Technological Pedagogical Content Knowledge (TPCK) (Hughes, 2005; Koehler et al., 2007).

TPCK incorporates three groups of knowledge (Content, Pedagogy and Technology), three dyadic components (Pedagogical Content Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge) and one overarching triad (Technological Pedagogical Content Knowledge) as seen in the figure below.

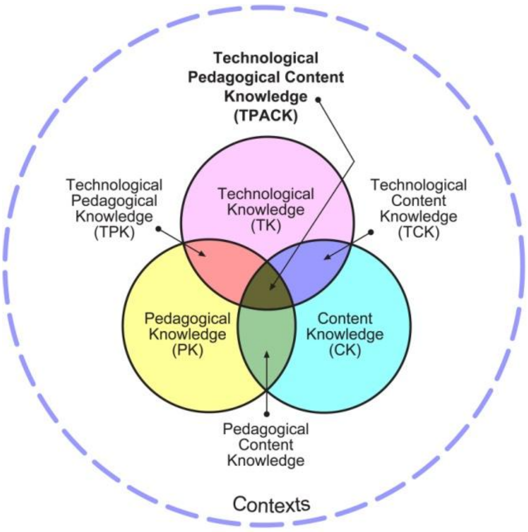

Figure 1: Technological Pedagogical Content Knowledge. From *TPCK- Technological Pedagogical Content Knowledge,* by Mishra & Koehler, 2008, Retrieved from website: http://tpack.org/

The interrelationship between each of these components needs to be taken into consideration. Hughes (2005) stressed that technology is not context-free and that good teaching requires an understanding of how technology relates pedagogy to content, rather than treating it separately. TPCK forms the foundation of good teaching with technology. It provides a case for the pedagogical value of such activities, especially when considering the integration of educational technology in pedagogy (Mishra & Koehler, 2006).

This knowledge emphasises the existence, components and capabilities of various technologies as they are used in teaching and learning settings. This may include an understanding that a range of tools exist for a particular task (e.g., fostering collaboration), as well as knowing what pedagogical strategies to use to get the most out of technology (Koehler et al., 2007).

Therefore, TPCK requires an understanding of how to use technology to illustrate concepts, an understanding of teaching methods that effectively use technologies and an understanding of how technology can be used to address the difficulties that arise when teaching concepts that may difficult to learn (Mishra & Koehler, 2006). It also requires:

'knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones' (p.1029).

Treating content, pedagogy and technology as separate is impractical according to the TPCK model (Mishra & Koehler, 2006). Although content, pedagogy and technology may play individual roles, teaching successfully with technology requires going beyond these individual roles to 'create, maintain and re-establish a dynamic equilibrium between each component' (Koehler & Mishra, 2008, p.20).

Using technology in science classrooms is important in today's society, especially given that much of science is dependent on technology (McCrory, 2008). Teachers need to use technology effectively in a way that addresses students' prior knowledge, encourages student engagement and builds on existing ideas. The integration of technology into science teaching has numerous advantages for teachers and students, the most important being that it is able to provide contextualised learning experiences for students. It also enables students to observe things they otherwise could not, including watching scientists at work or communicating with remotely-located science professionals (McCrory, 2008).

2.10 Information Communication Technology (ICT)

Teaching resources over the years have developed significantly. In recent years, information communication technology (ICT) has been at the forefront of teaching resources in education. The introduction and increasing prevalence of Information and Communication Technologies (ICTs) in education offers science education new opportunities and challenges. Its use has demonstrated a shift from traditional lecture-style classroom teaching (where students are passive learners) to an environment that fosters active engagement (Moore, 1989) and greater class participation (Frailich, Kesner, & Hofstein, 2009). ICT also provides teachers and students with access to a wide range of scientific knowledge that was not always readily available in the past.

ICTs have the ability to offer a wide range of science resources in schools. They provide easy access to a variety of internet resources and materials that facilitate and extend opportunities for enquiry both inside and outside the classroom (Osborne & Hennessey, 2003). Therefore they can act as a means to break boundaries between school science and current science issues and practices.

Students have benefitted from using ICT. According to McFarlane & Sakellariou (2002), young people react favourably to the use of ICT in the classroom. It empowers students with knowledge that extends beyond science textbooks and allows them to acquire information in real time. Successful teaching in ICT involves fostering the active participation of pupils with tasks that provides students with opportunities to demonstrate responsibility and engagement (Newton & Rogers, 2001). Computers allow for smaller, more intimate group interactions that give students greater control over their learning and promote peer learning (McFarlane & Sakellariou, 2002). They provide opportunities for students to revise, develop and visualise their ideas (Hennessey et al., 2007).

Student engagement with ICT resources depends on students' familiarity with the technology used. If unfamiliar tasks or resources are presented it may hinder student knowledge development and they may not be able to fully communicate their ideas or interact with the teacher (Cowie et al., 2010). Student disengagement may occur when the task is not challenging or the meaning is unclear. To increase student engagement with the subject, students should be provided with activities that are academically engaging and that foster positive emotions (Kearney & Treagust, 2001). This can be achieved through effective integration of TPCK within science teaching, which enables teachers to use strategies to promote teaching and learning with technology.

One example of ICTs that can be used by teachers are videos that are available through the internet, either through popular websites like Youtube or via purpose built websites. They represent easily accessible and familiar technology that teachers have used in the past and may continue to use in the future to enhance students' understanding of concepts.

2.11 Videos accessed through the Internet

Given the wide range of ICT resources available, this study utilised web-based videos to provide students with contextualised learning experiences. It aimed to better understand their impact on students' perceptions of science and to discover whether or not the strategies used made any difference to student understanding.

Web-based videos are a form of ICT used in science classrooms to help provide students with contextualised learning experiences. They can help students better understand core ideas, bridge knowledge from concept to context and focus more intently and they can increase the quality of presentations when used in the right context (Otrel-Cass, Cowie, & Khoo, 2009). They can help clear up misconceptions about science and they can help with 'conceptualising scientific events' (Bull et al., 2007, p. 132). However, using videos in class requires careful preparation and planning, to identify what to watch and when to watch it so as to support student engagement (Otrel-Cass et al., 2009).

Videos accessed via the Internet allow teachers and students to have greater control over the segments viewed—they allow random access and play videos at any speed up to real time in a forward or backward direction (Kearney & Treagust, 2001). This is not possible with videotapes because individual frames degrade when displayed for long periods of time and random access is difficult. However, these features are enabled if the video is digitised either on a computer or on a videodisc player (Kearney & Treagust, 2001).

Web-based videos also enable the viewing of dangerous, difficult, expensive or time consuming demonstrations not possible in a science lab (Hardwood & McMahon, 1997 as cited in Kearney & Treagust, 2001). It provides students access to sophisticated ways of observing events and viewing accurate and reliable replications of demonstrations (Bosco, 1984 as cited in Kearney & Treagust, 2001).

One example of video resources that are available through the Internet that this study utilised is from the New Zealand Science Learning Hub website (University of Waikato, 2007). This resource was compiled in response to the need for a resource that provides contextualised examples of science research and researchers (Cooper, Cowie, & Jones, 2010). The use of videos in this study enabled students to see dangerous experiments they may not have been exposed to or have thought of before and enabled them to observe a variety of scientists at work. The scientists portrayed in the videos used scientific knowledge in settings that students may have seen or heard about through media such as television.

2.12 Summary of the Literature Review

This chapter presented the literature that provided the background thinking for this study. As has been discussed, students' are increasingly displaying negative attitudes towards science as they move from primary to secondary school. Such attitudes have contributed to students' lack of engagement with science at school. There has also been a decline in the number of students wanting to pursue science in later school years. However, studies have suggested that students who enjoy science are willing to invest the effort required to do well.

Students' attitudes towards science are influenced by a variety of factors, including experiences at home and in the school environment. Students bring the wealth of their previous science understanding (also known as their funds of knowledge) into the science classroom. Effective use of this knowledge by classroom teachers can influence levels of interest in the subject. Understanding these forms of knowledge can also help in shaping students' attitudes towards the subject. It has been discussed that it is important for teachers to have an insight into students' prior understandings of science so that they can address these with the appropriate resources—enhancing their knowledge and correcting any misconceptions.

In addition, if the classroom experiences students are exposed to are not stimulating and challenging enough students will fail to engage with the subject. These experiences further shape students' science identity and the images they have of science. Students' science images may be limited to school contexts, given the experiences that can be gained from such a setting.

This chapter highlighted the findings of previous research, which suggest that to successfully influence students' attitudes towards science requires intervention prior to the age of 14. Such interventions must be meaningful and relevant to students' lives to keep them engaged with the subject. One example of an intervention is the use of context-based learning. ICT can be used to design contextual resources. When teachers provide resources that offer contextual examples about science and scientists using ICT resources such as Internet videos, they need to have some understanding of technological pedagogical content knowledge (TPCK). This understanding will enable them to effectively incorporate content, pedagogy and technology and thus effectively engage their students in science lessons.

CHAPTER THREE: Methodology

3.0 Introduction

This chapter presents the methodological framework adopted for this study and the methods used for data collection. The methods used included drawings, observations and interviews. This chapter elaborates on each of the methods used, discussing the advantages and limitations of each. The chapter further discusses issues regarding the reliability and validity of the data collected. This study involved human participants and therefore ethical considerations had to be taken into account. The analytical framework chosen for this investigation—the experimental design approach—is then discussed. This approach allowed evidence to be collected from the activities the participants engaged in (Tobin & Kinechloe, 2005). Following this, details of the intervention resources used in this study are given, and the chapter concludes with a summary.

3.1 Methodology

The research methodology describes the approach or paradigm that provides the basis for the choice and use of particular methods (Crotty, 1998). Paradigms are sets of assumptions about the world and what constitutes proper techniques for inquiring into that world (Punch, 2009). In any research, the researchers' opinions of these paradigms should also be considered, as the research is guided by the researchers' 'beliefs and feelings of the world and how it should be understood' (Denzin & Lincoln, 2005, p.22).

The methodology for this research reflects features of an inquiry paradigm (Punch, 2009). Within the social sciences, inquiry paradigms are based on assumptions about what makes up our knowledge of the reality being studied. These are addressed by three important concepts ontology (what can be known about the form and nature of reality), epistemology (the relationship between the knower and the known) and methodology (the techniques the inquirer uses to find out what can be known) (Punch, 2009). The ontology directs the epistemology, the epistemology shapes the methodology and the methodology determines the research methods or data collection methods that are used. These paradigms are interrelated and shape both how researchers interpret the world and how they behave in it (Denzin & Lincoln, 2005).

Kaplan (1973, as cited in Cohen, Manion, & Morrison, 2007) explains that methodology helps to determine the process of inquiry. This is significant because there are different views on how people make sense of “the nature of the phenomena that is being presented to their senses” (Cohen & Manion, 1994, p.1). Two of the most influential theories of knowledge in sociology are positivism and interpretivism. Positivism is typically associated with quantitative data collection methods, whilst interpretivism is associated with qualitative inquiry (Punch, 2009).

A positivist approach gives an objective account of the world—one that is based on scientific reasoning and principles rather than on interpretations of beliefs and opinions. Positivism views facts separately from values (Punch, 2009) and claims that science is able to provide the best understanding of knowledge (Cohen et al., 2007). Therefore, positivism asserts that it is possible to give objective accounts of the world (Denzin & Lincoln, 2005). A positivist approach would have been inappropriate for this study due to its scientific nature, disregard for subjective bias and the fact that it is best suited to studies with large numbers of participants (Cohen et al., 2007).

Qualitative inquiry is associated with the study of human nature as reflected by interpretivism (Denzin & Lincoln, 2005). The interpretivist approach allows researchers to view situations through the eyes of the participants, who can give an account of their understanding of situations (Cohen et al., 2007), and is suitable for smaller population samples. Interpretivist approaches take the subjective nature of participants views into account. They also acknowledge the meanings people bring to situations and use to understand the world (O’Donoghue, 2007, as cited in Cohen et al., 2007).

This research adopted the interpretivist standpoint that knowledge and reality are interpreted by the individual and are inherently subjective in nature. Such a position underpins the view that attitudes and ideas are shaped by the experiences participants’ have had, and cannot be revealed using a positivist approach (Cohen et al., 2007). Methods were chosen that would attempt to bring out the subjective opinions, interpretations and worldview of participants through the observation of discussions.

Methods are different approaches that are used in educational research to collect data (Cohen et al., 2007). They can be qualitative or quantitative in nature. The qualitative inquiry used in this study included qualitative and quantitative methods. Qualitative methods aim to collect subjective data, while quantitative methods collect objective and quantifiable data (Denzin & Lincoln, 2005). The next section will elaborate on the methods chosen for this research project.

3.2 Methods

This research was concerned with studying students' perceptions of science and scientists and the methods chosen had to allow some insight into students' thoughts, feelings and motives. With this in mind, the methods for data collection included drawings, observations and interviews. This section will first discuss methods that have previously been used to find out about students' perceptions of science and scientists.

3.2.1 Finding out about students' perceptions of science and scientists

To better understand students' perceptions of science and scientists, research studies such as the MOTIVATION project run by the European Commission (Thaler & Dahmen, 2009) and the ROSE study, which looked at factors important to the learning of science, have used combinations of questionnaires and interviews (Schreiner & Sjoberg, 2004). Another method that has been used to better understand students' ideas of science and scientists is the Draw-A-Scientist Test (DAST), which was used in this study. The original DAST was designed by Chambers (1983) and used students' drawings of scientists to learn about their perceptions, or conceptual images, of scientists (Tucker-Raymond, et al., 2006).

The DAST has been used in several studies (Barman, 1996; Chambers, 1983; Huber & Burton, 1995; Mason, Kahle, & Gardner, 1991; Matkins, 1996; Palmer, 1997; Song & Kim, 1999). This test focuses on stereotypical indicators identifying various characteristics that students attribute to scientists. Unlike the original DAST, which simply required drawings of a scientist, this DAST required that students create four drawings of scientists in their workplace. This adaptation was deemed appropriate for this study because it was able to provide richer information on students' perceptions of science and scientists. For example, Tucker-Raymond et al.'s (2006) study, which aimed to gain a better understanding of primary aged students' impressions of the role of scientists, also used the modified version of the DAST. The study involved students making two drawings of themselves as scientists, which were validated with interviews. Illustrations of scientists and actual views of science and scientists may not always be in agreement with each other (Bielenberg, 1997). These interviews enabled the students to more fully communicate their ideas about science and scientists and provided emergent knowledge of their understanding. It also wanted to provide students an opportunity to express more than one image of a scientist since images of scientists drawn by students may differ at different times (Maoldomhnaigh & Hunt, 1989).

3.2.2 Drawings – the Draw-a-Scientist Test

Drawings that have been produced by young people have enabled educational researchers to gain an insight into students' personal ideas about their own experiences of science (Haney, Russell, & Bebell, 2004). This is useful for informing teaching and learning practices.

Drawings as a participant generated visual method provides information on participants' own experiences. The images produced by participants may be a representation of themselves and their social world. Images generated by children can be powerful tools, as they broaden the scope of the data and give participants a sense of participation. They empower those whose voice may not usually be heard. This method of sharing ideas can be empowering for participants who find it difficult to express themselves in words and struggle to document what is meaningful to them. This method recognises participants as knowers (Guillemin & Drew, 2010).

Drawings for research can be structured or unstructured (Favara-Scacco, Smirne, SchiliroÁ, & Di Cataldo, 2001). Structured drawings help provide an organised external reality—the flexibility lies in allowing participants to make choices with regards to colours, materials and timing. In this case, participants would be provided with an outline of drawings and they would have the freedom to decide on its appearance through use of colour. Unstructured drawings, on the other hand, are used in situations where participants need to liberate their inner imaginations by illustrating it on paper (Favara-Scacco et al., 2001).

The Draw-a-Scientist Test (DAST) is an unstructured drawing exercise that has been used in a number of educational research studies (e.g. Bielenberg, 1997; Finson, Beaver &, Cramond 1995; Tucker-Raymond et al., 2006). The DAST was originally developed as an assessment tool to gather information on stereotypical images of scientists as perceived by children (Nuno, 1998). The information gathered using this tool provides an understanding of students' images of scientists, the professions they are associated with and the effectiveness of science instructional programmes (Nuno, 1998). Classroom teachers have also used this method to understand children's images of scientists, to initiate discussion (Barman, 1996; Huber & Burton 1995) and to evaluate the effectiveness of instructional programs aimed at changing students' attitudes towards science (Flick, 1990; Mason et al., 1991; Matkins, 1996).

Drawings have been used to help understand students' perceptions of scientists for over 50 years; educational research has specifically focussed on stereotypical indicators. Initially this tool used seven stereotypical image indicators to evaluate scientists' images. These were the presence of lab coats, eyeglasses, facial hair, symbols of research, symbols of knowledge, technological tools and captions that were believed to represent stereotypical views of scientists. However, the DAST has been expanded and revised with time to include eleven standard image indicators that were utilised in this study and expanded on in Chapter 4.3 Here the DAST has been used to analyse students' attitudes towards science using a check-list method (Matkins, 1996; Finson et al., 1995).

Information collected from this type of method can be useful in both understanding the attitudes displayed by students and in making future decisions. Researchers such as Finson et al., (1995), Flick (1990), Mason et al. (1991) and Palmer (1997) have found that students' stereotypical images influence their attitudes towards science. Stereotypical images of scientists are influenced by cultural models—students are exposed to these and they are then reflected in student drawings. These models arise from a number of sources including movies, television and comic books (Finson, 2010). Stereotypical perceptions have contributed to students' misguided ideas that scientists have to be outstandingly intelligent, work alone and have a limited social life. Students who feel they do not fit this mould may not pursue science as a career in later years (Finson, 2010).

Therefore, science education plays an important role in influencing students' perceptions of science. Educators need to be aware of the images students' may already have of science, which may be influenced by their misguided perceptions (Scherz & Oren, 2006, p.967). Being aware enables educational practitioners to better understand how they can improve their practices.

The DAST method is not free of limitations. One issue with the DAST is that it only provides a one-dimensional snapshot of students' mental representations of scientists (Tucker-Raymond et al., 2006). Drawings do not by themselves reflect students' innermost ideas about what has been illustrated in sufficient depth. This evidence alone may not be reliable—what students draw on paper may not fully express their perceptions of a scientist. To better understand students' impressions of scientists, researchers have used surveys and interviews. Any one of these methods used on its own can be especially problematic when used with young children because language is still being mastered at a young age. One method alone may not sufficiently extract what students know. A combination of methods, as has been used in this study, enables students to express their ideas in as many ways as possible; this explains the need for interviews and classroom observations to help interpret these drawings. Interviews and drawings provide multimodal opportunities for students to explain their ideas (Tucker-Raymond et al., 2006).

Another limitation is that the information gathered from the DAST on students' beliefs about and attitudes towards science can be interpreted in the same way for students of different ages. Conceptual changes in attitudes and beliefs would occur between kindergarten and university and the DAST cannot explain these changes—it can only document them (Thomas, Henley, & Snell, 2006). Other limitations are linked to students' perceived artistic ability, their relationship with and feelings towards the person who gives them the task, how demanding the task is and their motivation to participate (Thomas et al., 2006). As a result of these limitations, this research project decided to use drawings in combination with student interviews and observations.

3.2.3 Semi-Structured Interviews

Interviews are a useful tool in qualitative research. They collect information on "people's perceptions, meanings, and definitions of situations and constructions of reality" (Punch, 2009, p.144). Interviews can be structured, semi-structured or unstructured and may be one-on-one or group based. This study used semi-structured interviews for data collection due to their highly flexible nature, their capacity for producing in-depth data and the fact that they can be used with young participants. Semi-structured interviews use open-ended questions that enable research participants to express their views explicitly and allow the researcher to respond (Creswell, 2008).

Semi-structured interviews allow for effective probing and exploration of the notions brought to light by the participants. The use of open-ended questions and the lack of restraint that is common in more structured interviewing helps to provide useful and detailed personal information that cannot otherwise be observed (Creswell, 2008). This kind of interviewing technique is further enhanced through the use of prompts, which allow for longer and more detailed responses from participants (Hershkowitz, Lanes, & Lamb, 2007). In semi-structured interviews, prompts allow for conversational continuity and help generate new ways of collecting information from participants who may not otherwise be providing the researcher with enough feedback on the research topic (Leech, 2002). Participant voice is enabled in such a method, which reflects the intentions of an interpretive paradigm.

Semi-structured interviews of students are limited in that they have to try and make sense of students' explanations and gather quality information in a short period of time, given the limited attention span of students (Cohen et al., 2007). Information gathered from such a method provides filtered information as viewed by the interviewer and may also be deceptive as participants may only provide information that the researcher would like to hear (Creswell, 2008). Therefore, using interviews exclusively compromises the quality of what can be said due to the subjective nature of that data collected. It is necessary to employ other methods to gain a broader understanding of students' views and to support the data collected during interviews. Care needs to be taken to ensure that the researcher is not viewed as an authoritative figure, and, when interviews are conducted in groups, that students' responses are genuine rather than based on or prompted by other students' commentaries. Students need to feel comfortable when giving answers in front of their peers and any desire to please the researcher must be eliminated (Cohen et al., 2007). During the interview, the researcher also needs to be considerate of the conversation taking place by saying little to allow students' to talk or use ice-breakers to help individuals to talk (Creswell, 2008). In this study, semi-structured interviews provided an opportunity for students to explain to the researcher, who was a stranger to them, more about their drawings and their ideas about the scientists in the video clips from the New Zealand Science Learning Hub website. This study also conducted classroom observations. These revealed the nature of the classroom discourse when the students were watching the videos and discussing them with their teacher.

3.2.4 Classroom Observations

Observation as a data collection tool is useful for gathering first-hand information as events unfold (Creswell, 2008). Observation in this context allowed the observer to obtain descriptive information about participants (Cohen et al., 2007).

Collecting observational data requires an understanding of two important practical issues: firstly, how to establish the focus of the observation and secondly, how to record observational data (Punch, 2009). In identifying the focus of the observation, an understanding of the continuum on which observations lie is important. These range from structured (knowing in advance what to look for, or hypothesis-testing) to unstructured (not knowing clearly what to look for, or hypothesis-generating) observations.

This study used unstructured observations to extract information from classroom discussions as they unfolded. This enabled the researcher to gather 'live data from naturally occurring social situations' (Cohen et al., 2007, p.396). To achieve this, the participants had to be observed in their natural settings, with the researcher acting solely as a non-participant observer.

When recording unstructured observational data, the field notes need to provide sufficient information about the time, place and activities observed. Field notes need to be descriptive, providing information on the events, activities and situations that unfolded and can be expanded on soon after the initial observations.

This enables the researcher to keep an accurate record of developing events, should they have gone unrecorded initially (Creswell, 2008).

Like any other method, observations have limitations. When the researcher acts as a non-participant observer the difficulty is that they have no direct contact with the participants, and incorrect inferences may be made from data collected (Creswell, 2008). To prevent this from happening, it is important to employ other methods of data collection. The combination can help to clarify the evidence at hand. The presence of the researcher in the classroom may also impact on students' participation. Also, whilst taking field notes during observations, the researcher may not be able to capture all of the events as they unfold. Observations can also be time-consuming and there may be some difficulty interpreting the data (Cohen et al., 2007). For this research, observations were considered a useful way of obtaining additional information about the nature of the interaction and engagement that was generated when the videos were watched and then discussed. This information was considered during the interviews and later in the interpretation of the data. The use of multiple methods in this study has increased the reliability of the data collected.

3.3 Data Reliability and Validity

In qualitative research, the reliability of data relates to the 'degree of accuracy and comprehensiveness' of the data collected (Cohen et al, 2007, p.149). This also reflects the trustworthiness of the research. The integrity of any research lies in the researchers' ability to truthfully report their observations.

Lincoln and Guba (1985) emphasise that data reliability is based on the notion of dependability, and methods of establishing reliability include validating participant responses, debriefing by peers, triangulation, persistent field observations, reflexive journals and independent audits (Cohen et al., 2007). For the purposes of this study, the trustworthiness of the data was ensured through consistent instructions and through the use of different data collection methods to provide enriched information.

Validity applies to the meaning researchers infer from data (Cohen et al, 2007). Validity acts as a qualifying check or measure for the research and is often based on the standards the researcher deems appropriate in terms of the trustworthiness of the research (Golafshani, 2003). To increase the validity of this study, more than one method of data collection was used. This was done to prevent the researcher from being reliant on only one source of information when answering the research questions. In this study, the data collected using one method was verified through another. For example, drawings collected from students were followed up with interviews that provided an opportunity for students to express their ideas verbally.

The criteria adopted to ensure the reliability and validity of research studies must reflect the paradigms that support the research. Interpretive inquiry, as used in this study, aims to establish the truth in a way that can be verified by means of reliability, validity and triangulation (unlike a positivist approach, where truths are established through measurable and observable facts by means of replication).

The reliability and validity of qualitative research can be further strengthened and improved by means of triangulation. Methodological triangulation refers to the use of more than one method to collect data (Cohen et al., 2007). The use of triangulation strengthens a study. This combination of different methods provides an inquiry with richness and depth (Patton, 2001). The drawings, classroom observations and interview techniques used in this study enable more information to be presented by participants and thus reduce researcher bias. In addition to the methods used to collect data, the way in which the researcher conducts the research with the participants is important. When considering the most appropriate data collection tools, the researcher must be making sure the research is conducted in an ethical manner; this will be discussed next.

3.4 Ethics

Ethics considerations in research establish the boundaries between acceptable and unacceptable behaviour. Research must not only follow ethical guidelines from professional associations, but must also be tailored to suit the unique context (Creswell, 2008). Therefore, ethics should be a primary consideration for researchers throughout the research process, from defining the problem and collecting and analysing the data through to eventually writing the final report (Creswell, 2008).

Researchers are also faced with ethical dilemmas in their attempts to find a balance between the demands placed on them in their search for truth and their 'subjects' rights and responsibilities, which may be threatened by research' (Cohen et al., 2007, p.51). This gets more complicated when the research subjects are children, who do not have the same capability as adults to fully understand the research process and the implications of their involvement (Cohen et al., 2007). The researchers' role is therefore to make sure that all steps are taken to fully inform participants, and in the case of child participants, their parents or guardians, so as to meet all ethical obligations.

Children's participation in the research process raises additional ethical issues for the researcher, who must balance competence, power and vulnerability (Punch, 2009). Children may lack verbal competence in terms of their ability to comprehend and express abstract ideas. Researchers are viewed as a power figure, due to their age, size and status, and this may make it difficult for children to disagree with the researcher. In addition, children are vulnerable and may be open to (and unaware of) persuasion and influence (Punch, 2009). Measures need to be taken to address these issues in educational research.

These issues affect the researcher's choice of methods. Methods that do not consider the welfare of participants or that breach the researchers' moral and ethical responsibilities towards participants would not be deemed appropriate.

The researcher also needs to consider the means of gaining access to participants. This would usually be through their school where the researcher formally approaches the institution fully outlining the intentions of the research. Once approval has been gained from the school, the researcher needs to seek informed consent from supervising adults (including parents/guardians) and from the students. Researchers must ensure that students are not coerced into participating and must respect participants' rights to decline at any stage of the research process. It is important that confidentiality for students and the institution they belong to is maintained at all stages of the research process. The researcher must also ensure that no harm is caused to the participants. The information collected during the study should solely be used for the purposes of the study and securely store the data collected (Cohen et al., 2007).

For the purposes of this study, ethics approval was sought from the Research Ethics Committee at the University of Waikato. Following this, the school principal and class teacher were contacted. Informed consent was sought through letters sent to the principal, teacher, parents and students outlining all the implications of involvement in this study. The researcher exercised professionalism during all interactions with the school and participants. The responses of individual students were not shared with the students' teachers, nor were personal details used in the reporting of the data. In doing so the researcher did not breach the trust between participant and themselves (Cohen et al., 2007).

Measures were taken to ensure that the identities of the participants and school remained anonymous and all the information gathered was solely used for academic purposes. The research method used required a suitable theoretical framework, hence the use of an experimental design approach.

3.5 The Experimental Design Approach

This study used the experimental design approach as its theoretical framework. An important focus of experimental design is its aim to investigate interventions and their impact on improving the curriculum or teaching (Tobin & Kinechloe, 2005). Experimental designs, also known as intervention studies, use procedures in which the researcher determines whether an activity or material used during an intervention results in changes in their ideas for the participants (Creswell, 2008). Central to the experimental design approach is assessing what students know before, during and after an intervention, which can be achieved through pre- and post-tests (Tobin & Kinechloe, 2005).

An experimental design approach was chosen for the purpose of this investigation, which was to provide information about whether videos of scientists had an influence on students' perceptions about science and scientists. Experimental design was used to better understand if the learning strategy employed changed the students' ideas. Exploring students' understanding of science and scientists aligns with the tenets in the Nature of Science strand in the New Zealand Curriculum (Ministry of Education, 2007). This research explored whether videos about scientists influence students' perceptions of them. Video selection was based on the criteria explained in the next section.

3.6 Intervention Resources

The students in this study watched videos of scientists at work that were obtained from the New Zealand Science Learning Hub website (University of Waikato, 2007). This is a New Zealand online learning resource developed by educators and teachers together with New Zealand scientists. This website has been specifically designed for New Zealand science teachers and their students with close links to the New Zealand science curriculum. Selection criteria for the videos are explained in the following section.

3.6.1 Video Selection Criteria

Six videos were selected by the researcher to showcase a range of different scientists. The videos selected included an equal number of female and male scientists and covered different fields of study. The fields of study covered were biology, chemistry, astronomy, ecology, pollution and traditional Maori knowledge surrounding fungi. This selection was suggested to the teacher, with the option of changing or adding different videos from the website. After viewing the videos the classroom teacher decided to use the researcher's selection.

A brief description of each video is provided below.

1. **Hidden Taonga: Young Scientists (**Ms Rebekah Fuller)

This video features a University of Hawaii PhD student studying traditional knowledge of New Zealand fungi. She describes her passion for encouraging young scientists and talks about the need for culturally diverse scientists and how they can contribute to scientific knowledge. Duration: 38 secs

http://www.sciencelearn.org.nz/Contexts/Hidden-Taonga/Sci-Media/Video/Young-scientists/(quality)/hi

2. **Hidden Taonga: Fungi in the lab** (Dr. Peter Buchanan)

This video features a New Zealand scientist who is a Science Team Leader of Biosystematics at Landcare Research in Auckland. He describes the scientific procedure of growing fungi in the laboratory. He details how fungi that need to be studied are grown in an environment that will not grow other types of fungi. Duration: 1 min 17 secs

http://www.sciencelearn.org.nz/Contexts/Hidden-Taonga/Sci-Media/Video/Fungi-in-the-lab

3. **Space Revealed: Tools for the astronomer (**Prof. Denis Sullivan)

This video features an astronomer from Victoria University of Wellington, who explains the use of telescopes, photometers and digital cameras in his research. His work involves travelling to various parts of the world tracking the star EC20 058-5234 and collecting information on it using various technologically advanced instruments. Duration: 2 mins 13 secs

http://www.sciencelearn.org.nz/Contexts/Space-Revealed/Sci-Media/Video/Tools-for-the-astronomer

4. **Nanoscience: Making gold nanoparticles in micelles** (Mr. John Watt)

This video features a PhD student at Victoria University of Wellington demonstrating one way to make gold nanoparticles in the laboratory. John describes the chemical reaction that occurs inside tiny spheres called micelles, created by surfactants (soaps) when gold chloride is reduced to make metallic gold. Duration: 1 min 31 secs

http://www.sciencelearn.org.nz/Contexts/Nanoscience/Sci-Media/Video/Making-gold-nanoparticles-in-micelles

5. **Life in the Sea**: **Working as an ecologist** (Dr. Candida Savage)

This video features an ecologist from the University of Otago. She explains what the role of an ecologist is and talks about her work and what she enjoys about the job. Dr. Savage talks about the different components to her job, her love for the sea, and the connections her work has with that of other specialists. Duration: 1 min 39 secs http://www.sciencelearn.org.nz/Contexts/Life-in-the-Sea/Sci-Media/Video/Working-as-an-ecologist

6. H_2O On the Go: Point Source Contamination (Ms Angela Schipper)

This video features a demonstration of how models can be used to help illustrate scientific ideas. Models are useful in the work of scientists for testing hypotheses without harming the environment. Angela describes how to build an aquifer model and simulate a point source contamination of the groundwater with readily available resources. Duration: 1 min 9 secs

http://www.sciencelearn.org.nz/Contexts/H2O-On-the-Go/Sci-Media/Video/Point-source-contamination

3.7 Summary of Methodology

This chapter discussed the methodology and methods of data collection used in the study. This study, being qualitative in nature, adopted an interpretive mode of inquiry. This method was suitable for this research because of the subjective nature of the research; the intention was to better understand participants' perceptions. Participants' opinions were taken into account, as reflected by their experiences. They were able to express themselves in several ways.

The study used multiple methods of data collection, namely drawings, observations and interviews. The combination of three different methods was useful in that it provided richer, more in-depth information. This chapter also elaborated on how the study ensured the validity and reliability of the data collected.

This research dealt with human participants and so ethical considerations were taken into account at all stages of the research process. This helped ensure that neither the safety of participants nor their ability to participate freely was compromised. It also ensured that the researcher remained within the ethical guidelines framework.

The choice of experimental design as the theoretical framework was appropriate for the inquiry paradigm used. This framework supported the intervention selected. This approach helped reveal if the intervention used made any difference to students’ ideas about science and scientists.

CHAPTER FOUR: Data Chapter

4.0 Introduction

This chapter presents data gathered using drawings, semi-structured interviews and classroom observations. The data collected via these three different methods will help answer the key questions outlined in chapter one. This chapter starts by presenting the participants' backgrounds, followed by details of the method used for the Draw-a-Scientist Test. Following this is a presentation of the data collected from the Draw-a-Scientist Test and a discussion of students' existing perceptions of scientists and science.

The following section presents first the observations made during video sessions. Students' perceptions of scientists and science are presented next, based on the researcher's classroom observations.

The classroom observations are followed by the data from the group interviews with the students. The information from the interviews on students' perceptions of science is compared to the NEMP 2007 study. The chapter finishes with a summary.

4.1 Background of Participants and Research Procedures

This study involved 38 year eight students from an urban decile 10 school. The group was made up of 25 girls and 13 boys. The students were from four separate classes, each consisting of 10 students except for one, which had eight students. The teacher who volunteered to participate in this study was a specialist science teacher.

This study was designed to collect information using three methods of data collection.

The students participated in this study in their four class groups. First, the 38 students participated in a drawing activity. The drawing activity was conducted by the researcher in a single science period for all of the classes. This was followed by the students watching pre-selected videos and participating in a class discussion with their teacher, which was observed by the researcher. Lastly, students participated in interviews with the researcher. The students all received the same instructions.

All names used in this chapter are pseudonyms. Before collecting any information from students, informed consent was sought from the students themselves, their parents/ guardians, the class teacher and the school principal. This is in accordance with the University of Waikato (2008) ethical guidelines.

4.2 Drawings: Draw-a-Scientist Test (DAST)

Students' existing ideas of science and scientists were collated from data gathered from a drawing activity. Students were provided with a sheet of white A4 paper and the researcher demonstrated how to fold the page into quarters. Following this students were given five minutes of quiet thinking time and asked to think about the various jobs scientists have. Students were then asked to draw four pictures of scientists doing different jobs. If a student asked for further clarification, they were told to 'draw an image of a scientist in their workplace'. Stick diagrams were acceptable, as artistic talent was not being evaluated. They were also told that the drawings were for a research study and were not going to be graded. Students were allowed to use coloured pens and pencils if they liked and were given approximately 20 minutes to complete the drawings.

To analyse the drawings, Mason et al.'s (1991) scoring sheet of 11 standard indicators was used. These indicators are lab coat, eyeglasses, facial hair, symbols of research (test-tubes, flasks, microscopes, Bunsen burners, experimental animals, other), symbols of knowledge (books, filing cabinets, other), signs of technology (solutions in glassware, machines, other), male, captions (formula, equations, taxonomy), pens/pencils in pocket, unkempt appearance, alternative images (sinister, eccentric, neutral, positive, female and science discipline). Drawings were scored based on the above criteria and analysed for any obvious presence of stereotypical indicators. The scoring sheet had provision for the scoring of 'no indication', 'some indication' or 'great indication'. However, it was fairly easy to assess the presence or absence of an indicator. Sinister images of scientists were considered to be images that portrayed violence, evil or negative images. Scoring of eccentric images reflected 'nerdy' scientists, but this was subjective to some extent as it was based on the researchers' opinion of what a nerd looked like. Images of scientists smiling or with positive captions were considered to be positive images. The gender of the scientist was easy to determine in most cases and in the few drawings where the gender of a scientist was unclear, students clarified it during interviews. During interviews students were also asked to talk about their drawings and share their ideas about scientists.

4.2.1 Images of Scientists

The Draw-a-Scientist Test was conducted as a pre-test to reveal aspects of students existing perceptions of scientists and their ideas about scientific professions. In their drawings students did not draw many of the stereotypical features of scientists. Typically, the number of stereotypical features drawn decreased with the number of drawings students made as illustrated in the drawing given below:

Figure 2: Pre-test drawings of a scientist showing students' perceptions of science and scientists prior to the video intervention (Student 27).

In Figure 2 the first illustration in the top left corner shows a scientist wearing a lab coat and safety glasses. He is pouring a chemical solution from a test-tube into a flask over a Bunsen burner. In the second drawing in the top right corner, the scientist appears to be observing a specimen through a microscope while in the third drawing in the bottom left corner the scientist appears to be doing a forensic investigation on a dead person. The last illustration is of a scientist taking a blood sample from a dead person to determine the cause of death. The student in this example drew a scientist in a lab, possibly a chemist, then another scientist in a lab situation, followed by drawings of forensic scientists. Drawing images of scientists from various science professions was a common feature in most student drawings; chemistry and forensics related jobs were heavily featured.

In their four drawings, most students drew stereotypical features mainly in the first drawing and occasionally in the second drawing and concentrated on other aspects of the work scientists do thereafter. This included drawing items related to their occupations, such as equipment for collecting data or analysing samples.

Table 1 shows the students' drawings and the number of times each of the 11 stereotypical indicators (STI's) were used in one or more of the four drawings. The numbered items in bold represent each of the STI's used in Mason et al's (1991) study. Some indicators have been further divided into sub-categories. Indicators or additional categories marked with an asterisk occurred frequently.

Table 1: Draw–a–Scientist Test results organised into Mason's 11 (1991) indicators (n=38)

Stereotypical Indicators (STI)	No. of students using STI in 4 drawings	No. of students using STI in 3 drawings	No. of students using STI in 2 drawings	No. of students using STI in 1 drawing	Total no. of students that drew this STI in one or more drawings
1.Standard Images					
Lab coat	4	2	3	2	11
Eyeglasses	3	0	0	3	6
Facial hair	1	0	0	2	3
2.Symbols of research					
*Test-tubes	2	0	4	14	20
*Flasks	1	1	2	15	19
Microscope	0	0	0	5	5
Bunsen burner	0	0	0	0	0
Experimental animals	0	0	2	7	9
*Other (i.e. magnifying glass, telescope, etc.)	0	6	0	18	24
3.Symbols of Knowledge					
Books	0	0	1	5	6
Filing cabinets	0	0	0	1	1
Other	0	0	0	1	1
4.Signs of technology(products of science)					
*Solutions in glassware	1	1	6	12	20
Machines	0	0	2	5	7
Other	0	0	1	2	3
5.Captions (formulae, equations, taxonomy)	0	1	0	0	1
6.*Male	9	4	5	11	29
7.Signs/labelling	1	0	1	0	2
8.Pen/Pencil in pocket	0	0	0	0	
9.Unkempt Images	0	0	0	3	3
10.Alternative Images					
Positive(smiles)	0	0	4	6	10
Sinister(mad scientist,	0	0	0	2	2
Eccentric appearance (nerd)	0	0	0	0	0
Neutral	0	1	1	4	6
Female	0	2	2	0	4
11.*Science discipline	17	3	3	7	30

*Frequently occurring indicators

The data will be presented in order from least frequently occurring STI's in students' drawings to the most commonly occurring ones. Data were grouped in this way to present a clearer picture of these students' perceptions of scientists (based on their drawings).

An analysis of the students' drawings revealed that only a few students drew Mason et al.'s standard stereotypical indicators of scientists, namely lab coats, eyeglasses and facial hair. Although each of these indicators were used in a few drawings, most students did not draw scientists with eyeglasses and facial hair. The frequency of each indicator in students' drawings is presented in Table 1. The total sum of students that used each indicator is given in the last column on the right side of the table.

The combined presence of lab coats, glasses and facial hair, all of which have been identified as standard stereotypical features of scientists in other studies, was found in only eight of the 38 student drawings. These eight students drew STIs in all four of their drawings. Seven students drew a combination of the above stereotypical indicators in one of their drawings. Altogether, lab coats appeared 11 times in student drawings, while glasses and facial hair appeared six and three times, respectively. During a class discussion with the teacher one student commented that:

Victoria: You don't need to wear a lab coat all the time to be a scientist.

It was interesting to hear Victoria's comment, as it indicated that she did not hold a stereotypical view of scientists.

The study also investigated whether or not students had any gender specific preconceptions about scientists. In this example (Figure 3) a student drew both male and female scientists at work.

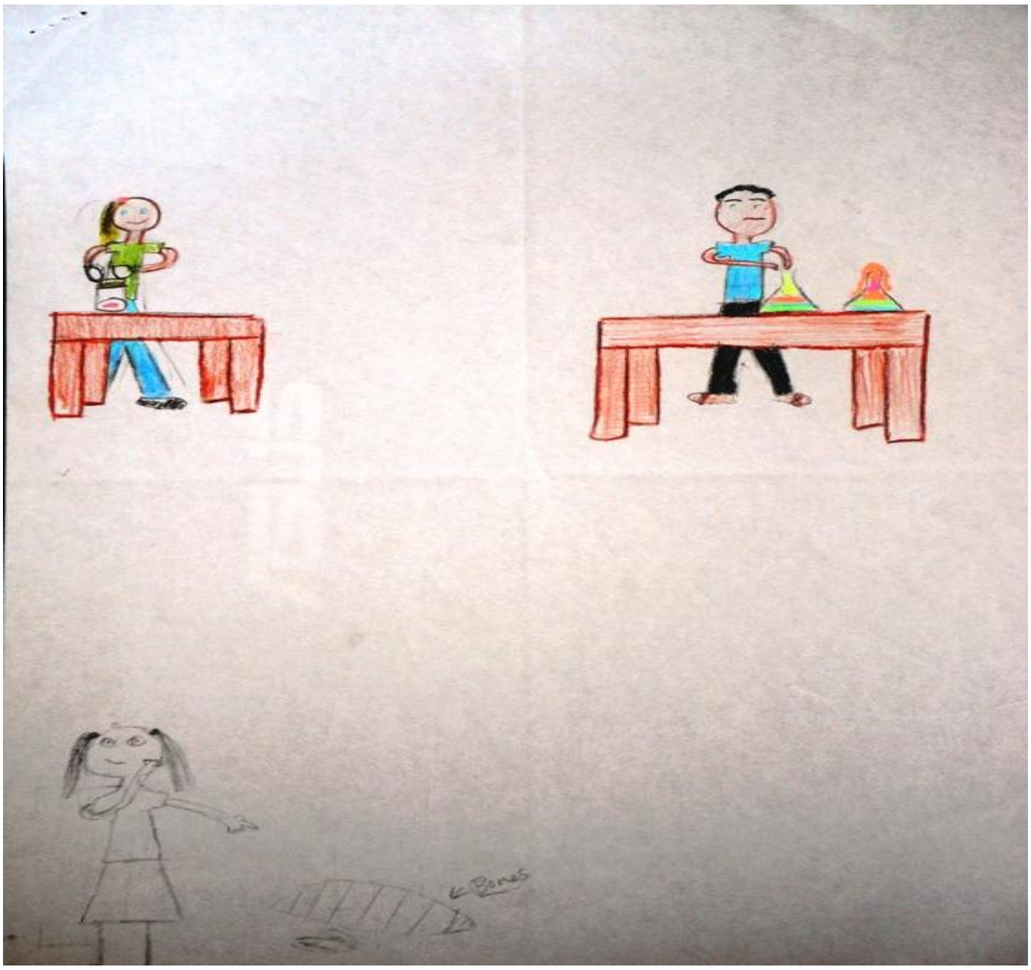

Figure 3: Drawings of male and female scientists (Student 26).

The stereotypical features of scientists that were drawn more frequently by students were those relating to gender, evidence of science discipline and some of the symbols of research and technology. Male images of scientists' appeared in 29 drawings, while female scientists were illustrated only four times. Male images of scientists were also evident in all four drawings (see the example in Figure 2)—this was common in most illustrations. Male scientist images have also been found to be common in students' drawings in other studies. Few drawings in this study included both male and female scientists as seen in Figure 3. No correlation could be drawn between the gender of the students and the gender of the scientists they drew. This was highlighted during their interviews with the researcher, when one of the students said:

Mark: People usually think that scientists are boys, but they are not always boys.

Some of the drawings used stick diagrams (Figure 4 and 5), which made it impossible to identify gender specific attributes—students even mentioned in their interviews that the scientists could be either. Only two students' drew clearly identifiable images of both male and female scientists.

Symbols of knowledge, like books, were not strongly evident either. Books appeared in six of the students' drawings, with one other drawing showing a filing cabinet. Another student drew a scientist using a clipboard to record notes, which was identified as being in the category of 'other symbols of knowledge'. Alternative images of scientists, which included sinister, eccentric, neutral and positive images, were hard to identify and could be identified as such in only a few of the student drawings. Whilst 10 students drew scientists in a positive image (smiling), only six students drew neutral images. Interestingly, while two students drew mad scientist images, none of the students illustrated scientists with an eccentric, nerdy appearance or with pencils in their pocket. These indicators have frequently been evident in students' drawings in other studies.

Although Mason et al.'s (1991) scoring sheet reports female images and science discipline under alternative images of scientists, I have chosen to report these in separate categories.

Unkempt scientist images were drawn by three students. Other stereotypical indicators evident in students' drawings were captions, which appeared in one drawing, and signs and labelling, which appeared in two drawings.

17 out of 38 students were able to identify four clearly identifiable professions that scientists are involved in, two of which were often chemistry and forensic science. Less frequently drawn images of scientists included illustrations of astronomers, teachers, rocket scientists, geologists, marine scientists, etc. These were not as evident as chemists and forensic scientists. Students generally appeared to have some understanding of the work of scientists and those with limited knowledge drew images reflecting their classroom experiences. The teacher explained that earlier in the year she had taught units on chemistry and forensic science. Drawings involving scientists at work studying weather patterns also featured in student drawings. During their interviews the students explained that in the previous year they had studied the weather, which explained why some

drew meteorologists. During interviews with the researcher, students made references to being exposed to extra science activities at home. Students commented that they used science websites and television at home to learn more, had parental help or borrowed books from the library to try experiments at home. This is evident in the drawing given below (Figure 4). The first illustration in the top left corner is of a NASA scientist declaring takeoff for a spacecraft. The second drawing in the top right corner is of a scientist who had created a new chemical to help plants grow faster. The third drawing in the bottom left corner is of an invisible cloak invention that can be used to spy on people, while the fourth drawing in the bottom left corner illustrates the discovery of a new planet. David explained that the fourth illustration was because he remembered watching a recent television news story on the discovery of planet X.

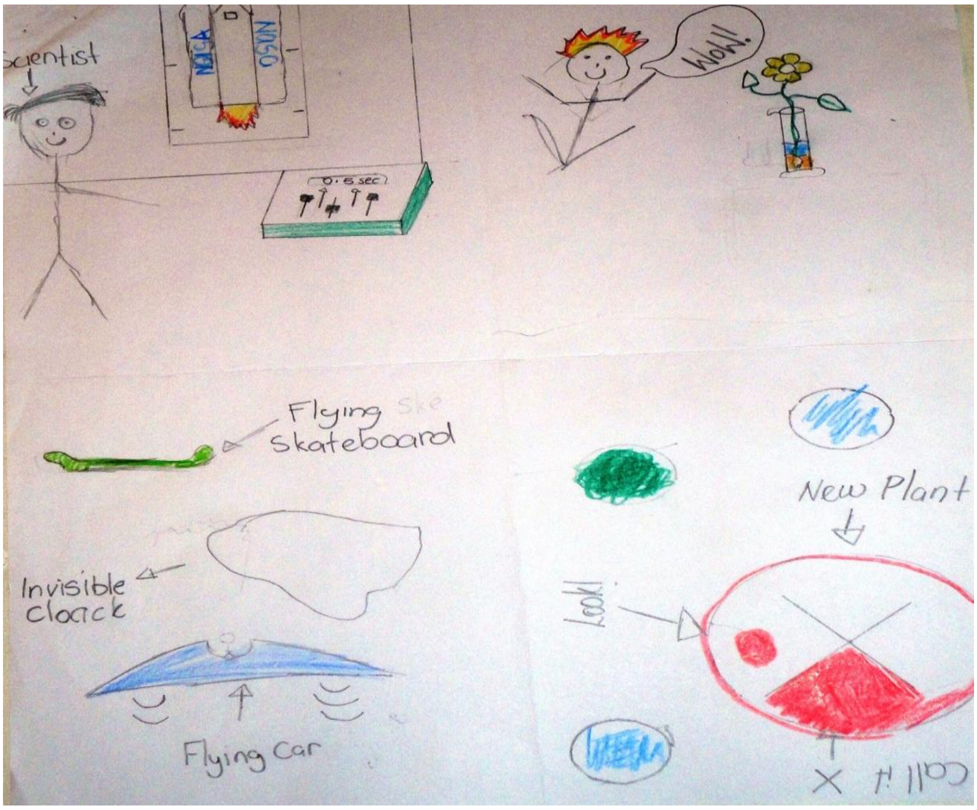

Figure 4: Drawings reflecting knowledge gained outside the science classroom (Student 32).

However, apart from a few examples (as in Figure 4), students' drawings represented what they had studied and experienced at school. Some students drew images of science teachers as scientists, as seen in the third drawing on the bottom left corner in Figure 5.

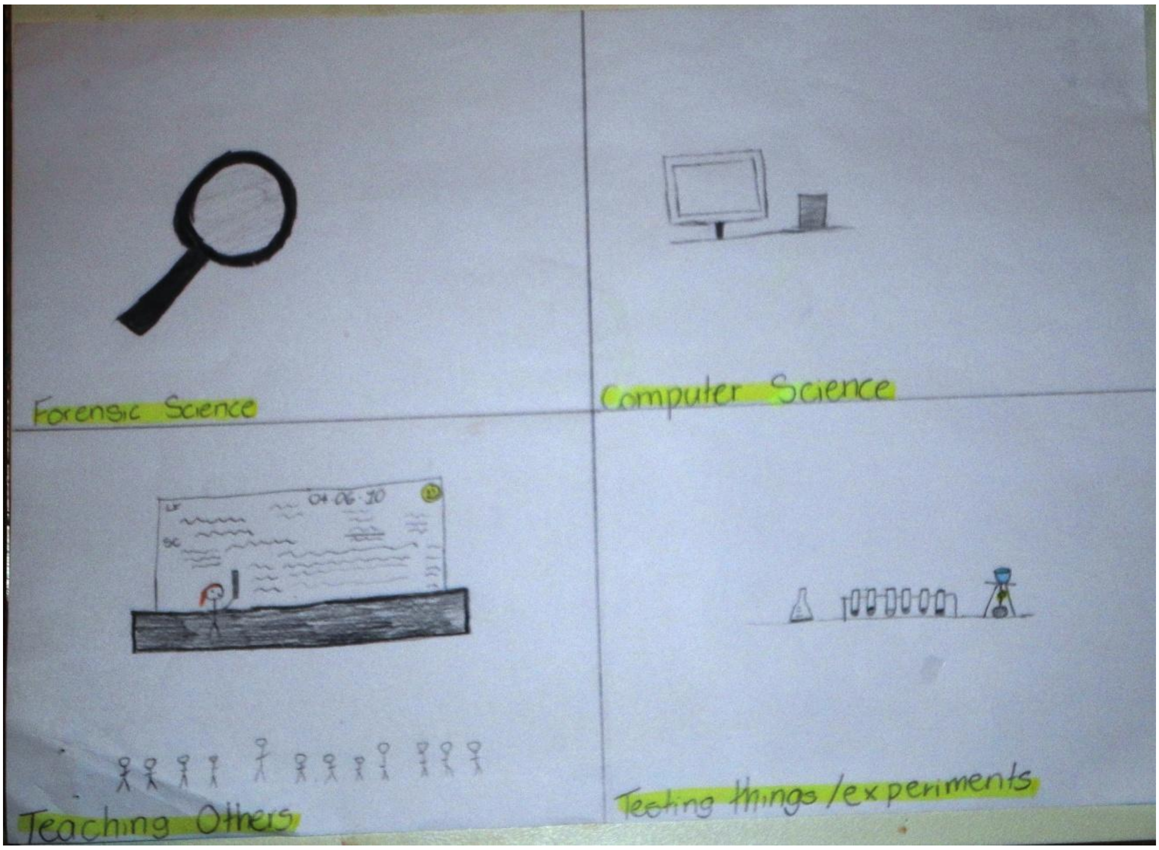

Figure 5: Drawings of stick diagrams and teacher as a scientist (Student 16).

During an interview with the researcher, another student commented:

Laura: Teachers can be scientists, just like our science teacher.

Laura further commented that she thought that her science teacher was a proper scientist and that she regarded her as quite intelligent and as someone who knew a lot about science.

A number of students did not draw actual images of scientists at work, but rather drew the science field they would be expected to work in. For example, some drawings indicated a chemistry lab with glassware, without a scientist at work (example Figure 5). Six stick diagrams were drawn that did not include or indicate any of the stereotypical physical features of scientists (Figures 4 and 5).

Symbols of research commonly drawn by students were test-tubes (Figures 2 and 5), which were indicated in 20 of the student drawings, and flasks, which appeared in 19 drawings. These were typically found in drawings of chemists. Generally, images of animals used for research did not show any signs of torture. Experimental animals were drawn by nine students and were mainly represented in the marine science field (see Figure 6). There was one drawing of a caged bird, but the image did not show any signs of torture. A couple of drawings showed illustrations of genetic engineering to create new species to help human beings with medical advancements. Other symbols of research drawn by students included equipment used by forensic scientists such as magnifying glasses (Figure 5), equipment used by astronomers, like telescopes and equipment used by scientists in general, like computers (Figure 6).

Figure 6: Drawings of symbols of research (Student 3).

Chemistry themes were strongly evident in student drawings, with 20 students drawing solutions in glassware to signify technology. However, six students drew machines, which included spaceships, rockets and new inventions. These images were further explained during interviews with the researcher as being linked to students' extra-curricular science activities. Some of the comments that students made were:

Peter: I made a hydro-car once and my dad likes me to do science things because he is a combustion engineer.

Levi: When I am bored I go to you-tube and watch clips on space school.

4.3 Students ideas about science and scientists after watching videos

Following the drawing activity, a video session was conducted by the classroom teacher. The videos were viewed a week after the drawing activity during a science class. Selected videos from the Science Learning Hub website were shown on a desktop computer and approximately ten students watched the videos and then participated in a class discussion. Videos on this website feature various scientists and aspects of the work they are involved in (see chapter 3).

During the viewing and class discussion the researcher sat at the back of the classroom and took notes on the discussion generated by the videos. The researcher was a non-participant in this activity. The discussion was facilitated by the classroom teacher, who decided which questions to ask. The relevance of the questions being asked was checked with the researcher prior to the video session. The same questions were asked of all the classes after the video sessions to ensure consistency between them.

The teacher began the discussion by getting feedback from the students on their recollection of the videos. The feedback was gained by probing students on their knowledge of scientists' occupations and science. Each video was addressed individually and students were asked to recall what they saw—what stood out for them. After this, general discussion-specific questions were asked, as given below:

1. What interesting things did you see in the videos? What was interesting about it?
2. What do scientists need to use to be scientists or to do their jobs?
3. Did you notice that some of the words used in the videos are words we have discussed in class? What were they?
4. What did you notice about the scientists?
5. What kinds of jobs do scientists do?
6. What else did you notice about the scientists that you had not thought of before? Anything different? Anything new?
7. What should scientists look like?

In addition, depending on students' answers the teacher would probe students with further questioning to seek clarification. For example, if a student found the equipment used interesting, the teacher would ask what aspects they found interesting and why.

During the class discussions and after watching the videos, students' comments indicated that watching the videos of scientists reinforced for them the fact that they held a 'media' image of scientists:

Peter: Glasses, lab coat, pen in pocket and bow tie is what you see scientists wearing on television.

Matthew: Science is very different to how it is described in the movies, which have chemicals and explosions.

Interestingly, these features were not evident in most students' drawings.

In addition to this, students' understanding of the symbols of research required in the working lives of scientists was broadened through watching the videos. Students commented that the scientists in the videos were required to use different types of equipment for their jobs. During the class discussions with the teacher, students said that scientists at times needed: instruments, chemicals, electric stirrers, technology, agar plates, food colouring, a boat, a camera, natural resources, thermometers, photometers and living organisms.

Students were also fascinated by the various pieces of equipment in the videos that they had never heard of or seen before. When the teacher asked what they found interesting about the videos of scientists at work, Molly said:

Molly: Early astronomers used their eyes for seeing but now they use telescopes.

Students recognised the importance and development of technology over time after watching the video of an astronomer at work, who explained how observations in astronomy had progressed. This video prompted them to recognise the importance of technology in the working lives of scientists. During the class discussion after watching the videos a student commented that:

Nic: We live in a generation of technology. People have begun to study more and have more knowledge.

After watching the video of the marine scientist, students commented that scientists do not work in isolation but require information from other areas of scientific expertise. During the class discussion with the teacher a student commented that:

John: Scientists rely on other professions for assistance with their jobs.

Students were surprised at the scope of science and its application to culture. After watching the video of a Maori scientist a student commented that:

Ebert: I didn’t know that Maori history and science research can be combined together.

Students recognised that science was not a gender biased field. After watching videos of male and female scientists at work students highlighted that women could be scientists too during discussion. For example:

Pearl: Some scientists were male and some were female. You don’t have to be a certain gender to be a scientist.

Students were surprised to hear that scientists used the same scientific terms they learnt about in class such as solute, solvents, salt, soap, sugar, molecule, hydrophilic, hydrophobic and cells. During the class discussion the teacher drew students’ attention to some of these terms, specifically ones they had used in their previous units of work.

Following the video session the students were invited to do a fifteen minute interview in groups of two during a separate science period. The interviews were conducted by the researcher to find out whether the videos had influenced the students’ ideas about science and scientists and to seek clarification on students’ drawings where required.

The semi-structured interviews provided an opportunity to listen to student explanations of their thoughts about the video session. The interviews made use of students’ drawings and videos to guide the discussion. All the interviews were recorded and transcribed with the students’ consent. The use of interviews to further investigate students’ drawings allowed participants to have a voice in the research process (Guillemin & Drew, 2010). The researcher was then able to interpret the drawings through the commentary of the participants (Cohen et al., 2007).

The student interviews were in three parts. Students were asked to reflect on their drawings, they were asked to think about whether the videos changed their views about scientists and they were presented with seven questions used in the 2007 NEMP (Crooks et al., 2008) survey, which explored students’ ideas about science and their interest in it.

At the start of the interviews students were verbally asked for permission to use their drawings for data analysis. They were also asked if they would like to be interviewed. This was done to allow the students to opt out of the study if they chose to. Each student was interviewed individually with their drawing. During the interview students' were asked 13 questions by the researcher (see Appendix E). Students were initially provided with 8 of the interview questions and were asked to write down their ideas; these were further discussed in the interview. This was done to prevent time wastage and speed up the interview process. The first question explored students' ideas about their drawings. Questions 2-4 sought feedback on the videos watched and students' perceptions of scientists. Questions 6-13 were adapted from the National Educational Monitoring Project (NEMP) 2007 study survey to help better understand students' ideas about science and their interest in it. Only seven out of the 12 NEMP study questions were used for this research. The remaining five questions had little relevance to the aims of this study, hence they were not included. The questions used were designed to elicit more information on students' attitudes and engagement with science—that is, how they see science in relation to themselves (Crooks et al., 2008, p. 63).

Most students found that the scientists in the videos were passionate about their jobs and led exciting lives because they experienced something new every day. Only a few students thought that they led a boring life.

During interviews with the researcher, students were asked if they found anything in the videos interesting. Students were surprised at some of the things they saw in the videos. Some of the comments made were:

Rachael: Some scientists looked very young; they didn't look like scientists at all.

Chris: They wore different clothes like suits as well as casual clothes.

Max: Scientists are normal people and they are not nerds.

Ellen: You don't need to wear a lab coat and gloves all the time to be a scientist.

Rebecca: They don't wear glasses or have mad spiky hair or wear lab coats all the time and not all of them are males.

When students' were asked during the interviews whether their ideas about scientists had changed between making the drawings and watching the videos, seven boys and seven girls stated that they still thought about scientists in the same way. All of these students considered themselves to be quite good at science and eight of these students participated in extra-curricular science activities, such as going to the library to get science books and doing science experiments at home.

24 students said that they felt their ideas had changed after watching the videos, as they had not previously observed or experienced the fields of science they saw in the videos. This group of students did not participate in extra-curricular science activities and they mainly experienced science at school. Some of the reasons students gave for changing their ideas about scientists included:

Vicky: I only knew about forensic scientists from what I learnt in class; now I know that there are a lot more different types of science jobs out there.

Peter: I only knew about scientists from what I saw on television. I never knew people studied fungi.

Chris: I thought scientists only worked in the labs, but they also go outdoors and find out about living things.

Molly: I didn't realise scientists are ordinary people and they help make our life better.

Some of the students had stereotypical ideas about gender and the role of scientists. During the interviews one student commented that:

Sean: Women did housework in the olden days but now they are scientists. People think that only men make better scientists but we have women scientists who can do an equally good job too.

4.4 Results from selected NEMP interview questions

The interviews inquired about students' ideas about science in addition to gathering information on students' understanding of scientists. This study used selected questions from the NEMP 2007 (Crooks et al., 2008, p.63) study to gather more information on students' perceptions of science. Students were given those questions beforehand and the researcher went through them with the students during the interview to make sure they were clear.

Selected NEMP questions

1. How much do you like doing science at school? (NEMP, Q1)
2. How much do you think you learn about science at school? (NEMP,Q2)
3. Would you like to do more or less science at school? (NEMP, Q3)
4. How often does your class do really good things in science? (NEMP, Q4)
5. How good do you think you are at doing science? (NEMP, Q6)
6. Do you do some really good things in science in your own time—when you're not at school? (NEMP, Q10)
7. Do you want to keep learning about science when you grow up? (NEMP, Q11)
8. Do you think you would make a good scientist when you grow up? (NEMP, Q12)

The students' sampled in this study were year eight students, just like one of the two sample populations of the NEMP study. However, the NEMP studies sampled students from 248 state, integrated and private schools across various deciles; this study worked only with a small selected group of students from a decile 10 urban school. Caution needs to be taken when comparing the data due to differences in the size and representational character of the population samples. The NEMP 2007 study results of Questions 1-4, 6 and 10-12 were used as a reference point when comparing the students' answers with the NEMP results. A summary of students' responses in comparison to the 2007 NEMP study is given below:

Table 2: 2007 NEMP questions about students' perceptions of doing science

Year 8 Interview Responses in % Study School (n=34), NEMP 2007 (n=2877)				
6. How much do you like doing science at school?	63 (24)	26 (39)	10 (33)	0 (4)
7. How much do you think you learn about science at school?	**heaps** 87 (10)	**quite a lot** 0 (39)	**some** 7 (40)	**little** 5 (11)
8. Would you like to do more or less science at school?	**more** 84 (44)	**about the same** 0 (46)	**less** 13 (10)	
9. How often does your class do really good things in science?	**heaps** 71 (2)	**quite a lot** 0 (18)	**sometimes** 13 (64)	**never** 21 (16)
10. Do you do some really good things in science in your own time—when you're not at school?	42 (3)	0 (12)	58 (54)	0 (31)
11. Do you want to keep learning about science when you grow up?	**yes** 76 (34)	**maybe** 24 (57)	**no** 5 (9)	
12. Do you think you would make a good scientist when you grow up?	21 (5)	39 (41)	39 (54)	

The results showed some differences between the study school and the 2007 NEMP study. When the researcher asked students' during their interviews about whether they liked doing science at school (Question six) or not, 24 students indicated they liked science a lot. Only four students stated that they did not like science and their reason for not liking science was that it was challenging for them. The NEMP study reported less students being positive about doing science at school (Crooks et al., 2008).

Students at the study school were quite positive about their science learning experiences at school. Interviews with the researcher showed that 33 students said they learnt a lot of science at school (Question seven) while 32 students felt that they would still like to learn more science at school (Question eight), suggesting an interest in the subject. Students reported having an enthusiastic and knowledgeable science teacher who made science lessons enjoyable. Results from the NEMP study reported far less positive responses from students.

Students at the study school also responded positively to the science learning experiences they had access to at school. 27 students at the study school stated that they did really good things in science, while eight students thought they did not do much in science at all (Question nine). Most students indicated in their interviews with the researcher that they were confident in their ability to do science. 21 students thought they were above average at science, while 10 students thought they were not good at science at all. The NEMP study revealed fewer reports of students in other schools having access to good science learning experiences in comparison to the study school.

58% students' in this study claimed that they sometimes participated in extra-curricular science activities. This was still slightly more than reported in the NEMP study (54%) (Question 10). The students who reported to engage in science activities said they did so out of interest or because their parents motivated them to do so. Students engaged in activities such as backyard science experiments from books, surfing the Internet to find information, visiting Stardome and, in the case of one student, making a hydro car with parental help.

Although students were generally positive about doing science at school and wanted to keep learning more when they grew up (Question 11), students' beliefs in their own ability to become good scientists were not very strong (39%) (Question 12). 29 students wanted to continue learning about science when they grew up but only eight students thought that they would make a good scientist. Although these numbers were higher than those in the NEMP (2007) studies, there were similarities. In both surveys fewer students responded positively to becoming a good scientist when they grew up than to wanting to learn more about science (this study 21%, NEMP, 2007 5%). 14 students indicated an interest in a science related field but were undecided as to whether that was their only choice.

4.5 Summary of Data Analysis

Combining three different methods to collect data was useful when making sense of student drawings and the observations during class time; it also helped provide a better understanding of the impact of videos on students' perceptions of science and scientists. Students' perceptions of science and scientists were illustrated through their drawings and the changes that occurred—if any—were revealed in the classroom discussions and semi-structured interviews.

The results obtained from the student drawings revealed that not all the stereotypical indicators of scientists as suggested by Mason et al.'s (1991) study were evident in this student cohort. Symbols of knowledge, standard scientist images of lab coats, a mad scientist appearance, goggles and facial hair were not often used as stereotypical indicators in students' drawings. Drawings of scientists commonly showed them as chemists, forensic scientists or weather scientists. These depictions were a result of their learning experiences at school. Scientists were also portrayed positively and, if identifiable, were mainly drawn as males.

Making four drawings gave students an opportunity to express their understanding of the science profession and most students were able to successfully do this. The images of scientists reflected by student drawings were associated with their classroom learning experiences around chemistry, weather and forensics and using standard lab equipment such as test-tubes and flasks. There were also some indicators of other science disciplines evident in student drawings. Students who had some prior experience of what a scientist did provided more details in their drawings such as equipment used for analysis, telescopes, etc.

After the intervention study using videos of scientists a number of students said that their ideas about scientists had changed. This was attributed largely to the things they saw in the videos that they had no prior knowledge of. Students' showed an increased awareness about the work of scientists, which was evident through their commentaries. They discussed scientists needing to work collaboratively with others and requiring the aide of scientific equipment to accomplish their tasks.

The videos appeared to have further impacted students' views of scientists in a number of ways: students showed an understanding of the many different areas scientists are involved in, that science is not a male dominated discipline but is inclusive of both genders and that images of scientists seen on television do not necessarily reflect reality. Classroom discussions with the teacher revealed that some students held a media image of scientists and were surprised not to see evidence supporting this in the videos. Students were also surprised to learn that scientists used words that they had come across in their classroom learning; this came up during a class discussion with the teacher.

The student interviews revealed that students who had an advanced understanding of the work of scientists invested time out of class in learning science. They were also quite fascinated to see that the field of science is much broader than they thought it to be, that it offers many jobs and that studies in science even extended into Maori culture.

In general, students at the study school demonstrated more positive attitudes towards doing and learning science at school, their science experiences gained previously and wanting to continue learning about science when they grew up. During interviews students attributed this to the specialist science teacher and the learning experiences made available to them at school.

In comparison to the NEMP 2007 study, students at this school were generally keen to learn more about science, were more positive about the subject and reported better learning experiences at school. Although they felt that it was important to know about science, selecting that as a career path was not an option for most students, which was a similar finding to that of the NEMP 2007 study. In both studies, similar numbers of students participated in extra-curricular science activities. Similar to the students in the NEMP study, students at the study school did not feel very confident about becoming a good scientist and a number of students indicated an interest in other fields.

CHAPTER FIVE: Discussion

5.0 Introduction

This chapter presents a discussion of this research. The chapter starts by highlighting the research questions set out in Chapter one (1.3). The research questions in this study were concerned with students' attitudes towards science. Of interest to the researcher were year eight students' perceptions of science and scientists and whether an intervention showing students videos of working scientists had any impact on their existing perceptions. The researcher gained insights into students' views using drawings and listening to them explain those drawings, as well as by observing classroom discussions and asking selected survey questions from the National Educational Monitoring Project (Crooks et al., 2008).

From the findings of this study, a number of themes emerged. These will be discussed here, as will the implications of this study for practitioners. Suggestions for further research will be made and the limitations of the research will be acknowledged. The themes that were identified were concerned with students' modern views of scientists based on their personal experiences; they had more than one idea about how scientists work. Their ideas of science and scientists broadened following a video intervention.

5.1 The study's aim

This study set out to gain a better understanding of students' declining interest in science, which has been linked to their attitudes. These can be influenced by many factors, including the relevance of science to students' lives and the ways science and scientists are portrayed at school and elsewhere. To influence these attitudes, it has been suggested that interventions need to occur prior to the age of 14, the age at which many students have been reported to lose interest in science. For this reason this study explored year eight students' ideas about science and scientists to see whether their views would be influenced by watching videos about scientists. Students' views were revealed using students' drawings, observations and interviews.

Specifically, this study set out to explore the following two questions:

1. What are year eight boys' and girls' existing perceptions of science and scientists?
2. Will the use of video narratives about a variety of scientists at work influence students' existing perceptions of scientists and science?

The following section highlights the findings of this study and presents the main body of argument based on what had been presented in previous sections.

5.2 Modern views of scientists based on personal experience

The students in this study produced modern images of science and scientists that reflected their understanding of and experience with the subject (Scherz & Oren, 2006). Their images of scientists were less stereotypical than reported elsewhere (Finson, 2010) and their explanations made it clear that they also drew on knowledge from school and elsewhere.

Earlier studies reported that students' ideas of scientists are often stereotypical, featuring elderly or middle aged males wearing white lab coats, glasses, featuring some type of facial hair and working in a laboratory (Barman, 1996). The contemporary images students in these previous studies produced frequently reflected media images of scientists, who often appear obsessive and insensitive (Finson, 2010). While some students in this study also drew on media images of scientists, this was not common. There was a decrease of the 'mythic stereotypes' (e.g. Frankenstein images') reported in Barman's (1996) study. The mad scientist image, of a man working alone in a laboratory, was not common among this group of students; students were sharing modern views of scientists working in a variety of fields. Specific science occupations depicted extended beyond the standard 'chemist' scientists working in labs and creating explosions to include scientists who were studying weather patterns, investigating crime scenes and studying astronomy. This was a different finding to what has been reported elsewhere (Barman, 1996).

The year eight boys and girls in this study generally represented scientists as males, contrary to evidence from other studies where student drawings featured less gender-stereotypical views of scientists (e.g. Bohrmann & Akerson, 2001; Bodzin & Gehringer, 2001). Students typically referred to scientists as being intelligent. This is a common perception, reinforced at times by classroom teachers (Finson, 2010); it suggests that science is something reserved for an intellectual elite.

This study also found that students drew on people, experiences and understandings they had encountered beyond the classroom walls and these funds of knowledge (Moll et al., 1992) became sources of authority for the students when they were talking about science and scientists. In their explanations the students in this study referred to images of scientists they had from when they participated in science activities outside of school and they also talked about NASA scientists, geologists, astronomers, meteorologists, etc. that they had seen on television or on science websites.

In addition to their funds of knowledge, students also drew on experiences with their teacher being a scientist. They discussed chemists, forensic scientists and meteorologists they had learned about at school. Students that reported having less outside school experiences of science drew on their classroom experiences more than students with more diverse sources of information.

5.3 More than one idea about the way scientists work

Students tend to have more than one idea about scientists based on their experiences (Guillemin & Drew, 2010) and this was evident in this study; students drew multiple scenarios involving scientists (Maoldomhnaigh & Hunt, 1989). Because the images people have of science have been described as unstable (Ryder et al., 1999, as cited in van Eijck et al., 2008), this study asked students to draw four images to enable them to illustrate more than one idea. Similar to Maoldomhnaigh and Hunt's (1989) study, less stereotypical indicators were drawn in this study after the first drawing, supporting the idea that students held more than one image of a scientist. The drawings showed that students knew of a variety of different types of scientists and how they worked. Some student drawings showed positive associations, where their work was about the betterment of the human race. Some of these positive images could be linked to the media, with television programmes having been reported to have a positive impact on student views of science (Flick, 1990).

5.4 Videos about scientists and science in support of class discussions

Students' initial thoughts about the work of scientists were still in some ways stereotypical. The intervention used videos from the New Zealand Science Learning Hub website (University of Waikato, 2007) and in discussion with the students it appeared that their perceptions were modified. These videos were specifically designed to support New Zealand teachers and encourage students to reflect on their current understanding of science and scientists (Cooper et al., 2010). The videos, in conjunction with the classroom discussions, prompted students to review their current views of scientists. The combination of viewing the videos and having discussions evidenced that technological pedagogical content knowledge (TPCK) supported getting students to think about the nature of science, and specifically the ways scientists work and communicate. The relationship between content, pedagogy and technology helped emphasise the significance of this activity (Koehler & Mishra, 2008). The videos provided relevant, authentic and contextualised learning experiences, such as observing scientists at work, which otherwise may not have been possible (McCrory, 2008).

After viewing the videos many students reviewed their understanding of scientists, the variety of specialised fields in which they study, their ages and gender and the fact that they often worked in groups rather than on their own. They recognised that the scientists they watched on video were at times the opposite to what they perceived them to be. Providing students in this study with examples of both male and female scientists made students recognise that science is not a domain reserved for males (Flick, 1990).

These contextualised examples allowed the students in this study to relate the subject to their daily lives (Bolstad & Hipkins, 2009). Students in this study felt that the terminology used by scientists was not foreign and difficult, but rather were similar to what they had learnt in class. This made science and scientists less abstract to them. The images students had of science were a reflection of their own scientific practices in- and outside school (van Eijck et al., 2008). In their reflections, students acknowledged having a limited amount of information on some of the jobs scientists did but that the videos helped them see that the work of scientists extended beyond the science laboratory and even involved cultural knowledge.

5.5 Implications for research

The findings of this study have possible implications for researchers interested in exploring students' perceptions of science and scientists and the preconceptions they may have. This study was carried out within a small group of students. The student group were from a high decile urban school with access to enriched learning experiences through a specialist science teacher and through the resources available at school. Future researchers might want to consider conducting this study with a larger sample of students with similar or different demography. A sample of similar demography could consider students within a similar decile school to see if the same or similar results are found, while a sample with a different demography could consider students from a number of different decile schools to explore whether there are any differences between students ideas about science and scientists. Given that this study used questions from the NEMP 2007 study (Crooks et al., 2008) a comparison with results from NEMP could be also interesting.

It may also be interesting to explore single-sex vs co-educational school settings or look at whether culturally diverse students find videos of scientists a valid source of information that shapes their ideas about science. Future research could also compare the difference between meeting real life scientists versus watching videos as part of the intervention.

The adapted Draw-a-Scientist Test (DAST) was a useful tool to better understand students' perceptions of science and scientists, because it used more than one drawing and students were asked to explain their drawings rather than leaving the interpretation to the researcher. Giving students five minutes of quiet thinking time was also useful in providing students with an opportunity to gather their thoughts. Allowing students to use stick diagrams for this study enabled students to be flexible in how they presented their drawings.

Drawings from the DAST were used as a prompt for student interviews. They provided a starting point for the conversation and enabled the researcher to gain a better understanding of students' perceptions of science and scientists. Using the DAST on its own can be limiting, as it only seeks to obtain information through drawings. Enabling students to have a voice through interviews in the research process provided depth and breadth to the information given by students.

Therefore it was important to use the DAST with other methods of data collection to obtain enriched student feedback and helped strengthen the method. Future research may want to employ a similar approach.

5.6 Implications for practitioners

This study revealed some interesting findings about students' perceptions of science and scientists that could be of interest to practitioners. The majority of the students at the study school had a positive attitude towards learning science at school but were not so keen to continue with science. These findings raise some important issues for practitioners. Teachers could use drawings and videos to explore what their students think about science, scientists and their own personal choices with regards to continuing with science in later school years. In this study the class discussion drew attention to aspects of science and scientists and provided students with the opportunity to share or hear about other students' ideas. This approach revealed information about their perceptions and provided opportunities to explore new perspectives on science and scientists.

It is also important to appreciate students' funds of knowledge and to create an environment where this information is valued so that students readily share experiences that may enhance their learning (Barton, 1998). To improve students' perceptions of science it is important to expose them to relevant science learning experiences using appropriate resources. One such readily available online resource is the Science Learning Hub website which shows a variety of scientists at work. Videos can support class discussion about science and scientists. This approach also fits in with the requirements of the New Zealand science curriculum, where the nature of the science strand highlights the need to understand how science and scientists operate (Ministry of Education, 2007).

5.7 Limitations of this study

This study was conducted on a small scale with a selected group of students; hence it had some inherent limitations. Since this study was limited in time, a smaller population had to be selected so that data from field work could easily be collected and analysed within the given time frame. The type of school selected was determined based on which school responded positively to the invitation to participate, and therefore represents a very select group.

This study did not ask students to produce another set of drawings after watching the videos, a process which may have provided more details about any changes in students' perceptions. The researcher only observed students over a very short period of time, so some factors that may impact on how attitudes are formed could not be considered, like students out of school science experiences. The study was also limited by the experience of the researcher.

5.8 Final thoughts

In this day and age it seems imperative that all students form a positive relationship with science so they can engage with this subject throughout their lives, whether they become scientists or not. It is important that students develop a positive attitude towards the subject and learn to engage with the subject (Baker & Jones, 2005). However, attitudes alone will not determine their choices in later years (Finson, 2010). Although students in this study school were generally positive about learning science at school and wanted to learn more, the number of students wanting to pursue with science in later years was still quite small. Resources such as the videos from the New Zealand Science Learning Hub website provided relevant material on science and scientists, which is aimed at improving student engagement with science (University of Waikato, 2007). However, to have enough confidence in oneself to continue with science, students may require more than hearing about scientists. This study showed that providing students with access to relevant contextualised learning resources about science and scientists meant that they were engaging in meaningful ways with the teaching resource, which is a proactive step towards creating opportunities to think about the relevance of science for students.

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APPENDICES

Appendix A: Letter to Principal

Dear Principal,

I am currently completing a Masters Education Thesis at the University of Waikato. For my thesis I am trying to find out about student's ideas about science and scientists. Hence, the study's research question is:

How does the use of video narratives of scientists in science classrooms impact student interest in science?

The two sub-questions of this research study are:

a) What are year 8 boys' and girls' perceptions of science and scientists?

b) Will the use of video narratives about a variety of scientists influence students perceptions of scientists and science?

For this reason I would like work with approximately thirty year 8 students at your school. I was hoping to be working with your year 8 science teacher who has indicated in an informal discussion their interest in participating in this research study. This letter is to request permission for year 8 students from your school to take part in a study.

I would like to involve the students in a drawing activity, a video session and a face-to-face semi-structured group interviews.

For the drawing activity the students will be asked to illustrate their ideas of scientists at work. This will be followed up by a video session that involves watching videos of scientists in various fields at work. Student group interviews will be conducted by interviewing all students in pairs to discuss their ideas on the first two activities.

This will occur at a time specified and suitable to the teacher and the students but during class time sometime during May/June 2010.

It is hoped that the information generated from this research will help gain a better understanding of students' perceptions of science and scientists and whether videos of scientists would influence these perceptions.

Results of the study may be used for my thesis and at presentations to an educational audience at conferences or in academic journals. Upon completion the school will be given a summary of the study.

Any information collected for this project will be confidential to the researcher and held in a secure location. Your school, teacher and students will not be identified

If you consent to this research at your school I would appreciate it if you could complete and return the attached consent form in the envelope provided. I am looking forward to the science teacher and year 8 students' involvement in this study. If you have any further questions about this project, please do not hesitate to contact me by phone or email. For any unresolved issues you may also contact my supervisor, Dr Kathrin Otrel-Cass at the University of Waikato.

Kind regards

Chhaya Narayan

Principal Consent Form

I have read the Information Sheet. I understand that:

1. My school will not be named.
2. The science teacher's and year 8 students' participation in the project are completely voluntary.
3. Students who decline to participate will still participate in the scheduled class activities including doing the drawings and watching the videos but no data will be collected from them.
4. The science teacher will be taking part in two phases of the research: drawing activity supervision of 40 minutes and a video session of 15 minutes.
5. Approximately thirty year 8 students will be participating in a 40 minute drawing activity, a 1 period video watching session followed by a 15 minute group interview of 2 students at a time with the researcher.
6. You, the teacher and her year 8 students have the right to withdraw from the project at any time.

7. The interviews will be audio taped and notes will be taken during the interview. The drawings will be done on paper individually and field notes will be taken from class observations of the video session.

8. Feedback from student interviews may be used for the study.

9. Data will be kept confidential and securely stored.

10. The study aims to be conducted in May/June 2010. Data obtained during the study of will be used to inform my master's research with the University of Waikato. Some of the work may also be presented at conferences with the educational community. All data will be reported anonymously so that the confidentiality of all participants is maintained.

11. I can direct any questions to Chhaya Narayan.

12. For any unresolved issues, I can contact the supervisor, Dr Kathrin Otrel-Cass at the University of Waikato.

Please complete and return the consent form in the self-addressed stamped envelope provided to Chhaya Narayan.

I am happy for the science teacher and year 8 students at my school to be involved in the research study under the conditions set out above:

Yes ____ No ___

Please print your name clearly:

Your full name: ______________________________

Signed: ____________________________________

Date: ______________________________

Thank you very much for your participation and help.

Appendix B: Letter to the science teacher

Dear __________,

I am currently completing a Masters Education Thesis at the University of Waikato. For my thesis I am trying to find out about student's ideas about science and scientists. Hence, the study's research question is:

How does the use of video narratives of scientists in science classrooms impact student interest in science?

The two sub-questions of this research study are:

a) What are year 8 boys' and girls' perceptions of science and scientists?

b) Will the use of video narratives about a variety of scientists influence students perceptions of scientists and science?

I would like work with you and thirty year 8 science students at your school as has been indicated in our email discussion. This letter is to request permission for your year 8 students to take part in a study.

I would like to involve the students in a drawing activity, a video session and a face-to-face semi-structured group interviews.

For the drawing activity the students will be asked to illustrate their ideas of scientists at work. This will be followed up by a video session that involves watching videos of scientists in various fields at work. Student group interviews will be conducted by interviewing all students in pairs to discuss their ideas on the first two activities.

This will occur at a time specified and suitable to you and the students but during class time sometime during May/June 2010.

It is hoped that the information generated from this research will help gain a better understanding of students' perceptions of science and scientists and whether videos of scientists would influence these perceptions.

Results of the study may be used for my thesis and at presentations to an educational audience at conferences or in academic journals. Upon completion the school will be given a summary of the study.

Any information collected for this project will be confidential to the researcher and held in a secure location. Your school, teacher and students will not be identified.

If you consent to this research at your school I would appreciate it if you could complete and return the attached consent form. If you have any further questions about this project, please do not hesitate to contact me by phone or email. For any unresolved issues you may also contact my supervisor, Dr Kathrin Otrel-Cass at the University of Waikato.

Kind regards
Chhaya Narayan

Teacher Consent Form

I have read the Information Sheet and I understand that:

1. My participation in the study is completely voluntary.
2. I will be involved in assisting with the research study with my year 8 students.
3. I have the right to withdraw from the project at any time.
4. The interviews will be audio taped and the researcher will also make field notes. The recordings will be fully transcribed and used where notes have been insufficient.
5. Data will be kept confidential and will be securely stored.
6. The study aims to be completed by June 2010.
7. Data obtained during the research study will be used to inform research on student engagement in science and will be used in a report for my Masters thesis with the University of Waikato. Some of the work may also be presented at conferences with the educational community. All data will be

reported anonymously so that the confidentiality of all participants is maintained.

8. I can direct any questions to Chhaya Narayan.
9. For any unresolved issues, I can contact the study supervisor, Dr Kathrin Otrel-Cass at the University of Waikato.

Please complete and return in the self-addressed stamped envelope provided to Chhaya Narayan.

I am willing to be involved in the research study under the conditions set out above.

Yes _____ No _____

Your full name: ___________________

Signed: ________________

Date: _____________

Thank you very much for your participation and help

Appendix C: Parent/Caregiver and student information sheet and consent form

Dear Parent/Caregiver,

This letter is to confirm that your son/daughter (insert student's name) indicated an interest to take part in a research study on student engagement with science. I am currently completing a Masters Education Thesis at the University of Waikato. For my thesis I am trying to find out about student's ideas about science and scientists. Hence, the study's research question is:

How does the use of video narratives of scientists in science classrooms impact student interest in science?

The two sub-questions of this research study are:

a) What are year 8 boys' and girls' perceptions of science and scientists?
b) Will the use of video narratives about a variety of scientists influence students perceptions of scientists and science?

For this study I would like to ask your permission for your son/daughter to participate in a drawing activity, a video session and a face-to-face semi-structured group interviews. For the drawing activity the students will be asked to illustrate their ideas of scientists at work. This will be followed up by a video session that involves watching videos of scientists in various fields at work. Student group interviews will be conducted by interviewing all students in pairs to discuss their ideas on the first two activities.

This will occur at a time specified and suitable to the teacher and the students but during class time sometime during May/June 2010.

It is hoped that the information generated from this research will help gain a better understanding of students' perceptions of science and scientists and whether videos of scientists would influence these perceptions.

Results of the study may be used for my thesis and at presentations to an educational audience at conferences or in academic journals. Upon completion the school will be given a summary of the study.

Any information collected for this project will be confidential to the researcher and held in a secure location. The school, teacher and students will not be identified.

If you consent to this research I would appreciate it if you could complete and return the attached consent form. If you have any further questions about this project, please do not hesitate to contact me by phone or email. For any unresolved issues you may also contact my supervisor, Dr Kathrin Otrel-Cass at the University of Waikato.

Kind regards
Chhaya Narayan

Parent /Caretaker and Student Consent Form

I have read the Information Sheet and I understand that:

1. My son/daughter's participation in the project is completely voluntary.
2. If my son/daughter declines to participate they will still participate in the scheduled class activities including doing the drawings and watching the videos but no data will be collected from them.
3. The school principal has agreed for this study to be undertaken.
4. Your son/daughter will be taking part in no more than three activities.
5. My son/daughter has the right to withdraw from the project at any time.
6. The interviews will be audio taped and the researcher will also make field notes. Drawings will be collected with your permission.
7. Data will be kept confidential and will be securely stored.
8. The study aims to be completed by June 2010.
9. Data obtained during the study will be used to inform research about gender and science education and will be used in a report for my direct study with the University of Waikato. Some of the work may also be presented at conferences with the educational community. All data will be

reported anonymously so that the confidentiality of all participants is maintained.

10. I can direct any questions to Chhaya Narayan.
11. For any unresolved issues, I can contact the study supervisor, Dr Kathrin Otrel-Cass at the University of Waikato.

Please complete and return to the students' science teacher

I am willing for my son/daughter to be involved in the research study under the conditions set out above.

Yes _____ No _____

Your full name: ___________________________________

Signed: ____

Your son/daughter's full name:______________________

Signed: ____

Date: ____

Dear student,

I am working with your teacher on a research project which gathers information from students on their perceptions of science and scientists in general. The goal of this study is to find out if the use of videos in a classroom has any impact on your understanding of science and scientists in general.

Your involvement in this study involves three activities; a drawing session, a video session and an interview. You teacher will conduct the drawing activity with you which will be collected with your permission or digital photographs taken should you wish to take your original work with you. At a separate time you will be asked to watch selected videos. During this video session I will be spending time in your classroom observing your classroom discussion. At a later stage you will be invited for an interview with another classmate to discuss your drawings and observations from the video session

Your name will not be used in our reports. You can ask to leave the study at any time but the teacher and the other students will still be part of the study. As a researcher I will still be in the classroom but I will not take notes or photographs of you. You can also refuse to answer our questions at any time.

The school will receive a copy of our report. Our results will also be reported through published papers and conference presentations.

If you consent to this research I would appreciate it if you could complete and return the attached consent form in the envelope provided.

Please complete and return to the science teacher

Informed consent

I have read the information provided on the *science and scientists* study. I am happy to take part in the study.

Signed: ________________________

Name: _________________________

Date: __________________

Thank you very much for your participation and help.

Appendix D: Student instructions for DAST drawings

Before you start the drawing activity you will be allowed five minutes of quiet thinking time. Use the time given to think about the different jobs scientists do. Please draw four different images of scientists doing science. You can use black and white or colour pencil. Stick diagrams will be accepted.

Appendix E: Semi structured interview questions

Semi structured interview questions that the interviewer may discuss within the interview timeframe

1. Please tell me about your drawings.
2. Can you tell me what you remember from watching the videos in class?
3. What did you find interesting in the videos?
4. Please look at the drawings you made again and think about the videos you watched - have your ideas about scientists changed since you watched the videos? Tell me about it?
5. Is there anything else you would like to add to the feedback on your drawings or video sessions?
6. How much do you like doing science at school?
7. How much do you think you learn about science at school?
8. Would you like to do more or less science at school?
9. How often does your class do really good things in science?
10. How good do you think you are at doing science?
11. Do you do some really good things in science in your own time — when you're not at school?
12. Do you want to keep learning about science when you grow up?
13. Do you think you would make a good scientist when you grow up?