

School of Education

**Associations between Differentiation in Secondary Science
Teaching Activities and Student Motivation to Pursue a Career
in a Science Related Field**

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**This thesis is presented for the Degree of
Doctor of Science Education
of
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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any University.

Signature: A handwritten signature in blue ink, appearing to read 'Nadhel', is written over a horizontal dotted line.

Date: 26 June 2017

Preface

I have been teaching in a variety of schools in Auckland, New Zealand for over 20 years at Secondary level. The schools have varied in their ethos, decile rating and curriculum. I have taught a range of subjects including science, technology and mathematics.

I have always been interested in continuing to research new ways to help my students as I believe teachers should continue to upgrade their knowledge with professional development and keep abreast of new technologies, strategies and concepts that aid in teaching.

Differentiation has always been a passion for me and finding new ways of achieving this has been an exciting journey for me. I have enjoyed finding out about the Layered Curriculum and aim to continue using this approach in my teaching. I find I am never too old to learn new things and the journey continues for me even if my thesis is complete.

Notes on style

Please note that this thesis is using the APA6 style of referencing and format for this thesis. This is a requirement for Curtin University.

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Abstract

Previous research has shown that the number of secondary students who elect to study science at a tertiary level in New Zealand continues to decrease with an inevitable consequence being that people trained in science are decreasing and unable to meet societal demands in careers that involve science (Hipkins, & Bolstad, 2005). This study set out to examine whether a Layered Curriculum approach to differentiated learning may be associated with self-selection of science based careers and student motivation to learn science at secondary school. The differentiated programs used in this study were layered to offer higher levels of thinking when compared with traditional approaches and incorporated different learning styles.

To investigate whether students were more likely to pursue science at higher levels of education, this study used Nunley's (Nunley, 2004, 2007) differentiated programs of work as the basis of the layered activities which incorporated ICT; Gardner's Multiple Intelligences and Bloom's taxonomy. In addition, a variety of different instruments including a four-item attitude to science survey was used, in the form of the TOSRA, to gather perceptions of student attitude to science and the Ideas in Science Survey. This study used a multiple methods approach and combined various qualitative methods to enhance triangulation and to improve the degree to which participant views were expressed in the data.

The major findings were: The use of a Layered Curriculum approach to differentiated learning leads to improvements in student enjoyment of science lessons allowing students to become more interested, engaged and motivated to take science as well as leads to enhanced student achievement. Differentiated programs of work encourage students to self-regulate allowing students to have a sense of personal agency and levels of self-efficacy. The use of differentiated programs of work encourage students to select science in subsequent years and perceive the choices prescribed for differentiated programs sufficient to match their learning styles. Various forms of differentiation allow for higher level thinking for the majority of students and encourage student aspirations for their assessment level. Recommendations for the future included broadening the study to include a larger sample, a variety of types of schools and different subjects.

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This has been a very exciting journey for me from the time I began on this quest through to its completion. I have grown as a person during this time as well as a teacher. I have a number of people to thank who have helped me along the way achieve this momentous goal of completing my thesis.

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I would also like to thank my family for the all times things were put on hold so I could spend time working on my research. To my husband, Richard for all the extra cleaning and cooking duties he has taken on so I could continue with what I was doing. To my darling daughters, Cenedra and Paige, for not disturbing me at critical times on my journey and allowing me to get on with the job at hand. I thank them all for their patience and words of encouragement when I was feeling frustrated that things were not going to plan and for believing in me.

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Chapter 1

Introduction to the Study

1.1 Introduction

During the 21st century we have begun to move into the knowledge age and there has emerged a definite shift in the way society works, both socially and economically (Bull, Gilbert, Barwick, Hipkins, & Baker, 2010). According to this research the emphasis is increasingly on knowledge and innovation with a decline in demand for unskilled jobs and an increase in more creative and technological careers. Bull, Gilbert, Barwick, Hipkins, and Baker, (2010) state that employers want employees who can work independently, are adaptable, can problem solve and can quickly adapt and learn new skills as well as take responsibility for all parts of a project. These people are often sourced globally, and not limited to local communities, and are frequently required to interact with others from around the world in order to perform their jobs (Kraimer, Takeuchi, & Frese, 2014). The evolving workplace will therefore draw people from different nations and these people must be able to communicate and understand each other (Bremer, 2006).

Globalization is “the reality shaped by an increasingly integrated and connected world economy, new information and communications technology (ICT), the emergence of an international network, the role of the English language, and other forces beyond the control of academic institutions” (Altbach, Reisberg, & Rumbley, 2009, p.33). Effective leaders will be those people who can interact with, understand and respect people from other cultures (Bremer, 2006).

Furthermore a global society requires students going on to higher education to have the opportunity to be involved in transnational education (Bannier, 2016) in which students are able to participate in courses in other countries without physically being there. Other names for this type of learning may include distance education, on-line education, collaborative education, for-profit education and satellite campus teaching. These types of programs offer collaborative learning opportunities, which are valuable for increasingly globalised societies and according to Bannier (2016), hold great potential for developing countries.

Young people have a different perspective to knowledge than the previous generation (Bull et al., 2010). According to their research teachers, other adults and books are not students' main source of information and schools are often viewed as "being irrelevant, slow-moving and something to be endured." In order for students to compete in today's society they need to have the skills to deal with problems faced by the real world (Lombardi, 2007). This way they will have the skills to be able to compete in a global job market. Subjects at school need to be more applicable to their lives (Big Heart, 2006). In a technically dependent society traditional methods of instruction are not meaningful (Bull et al., 2010) and will often include lecturing to the students and writing on the board style of teaching (Chandra, 2004). Multimedia technology provides a means to allow students to learn interactively thus motivating them and involving them in their learning (Bethel, & Lieberman, 2013; Neo, & Neo, 2001).

The development of interactive multimedia and web-based learning is crucial to the provision of authentic learning environments that better prepare students for today's world (Tan, Kwok, Neo, & Neo, 2010). Tan, Kwok, Neo and Neo (2010) stated that students are more engaged and actively involved in the learning process when interactive authentic learning activities are incorporated into their learning. Findings in the literature have shown that students found the learning process to be more relevant and interesting (Tan, Kwok, Neo, & Neo, 2010). Web based learning allows educators to offer a variety of ways of teaching rather than using existing traditional teaching methods alone (Chandra, 2004). Web based learning must be well designed, interactive, engaging and involve multiple media types (Tan et al., 2010). The focus shifts from the teacher to the student (Herrington, & Kervin, 2007). A web based learning environment can be defined as "a computer-based and computer supported education and training system that uses the web as the representation and delivery medium of learning materials" (Tan et al., 2010, p.952).

If students and teachers possess good technological skills and teachers show an interest in using ICT and involve their students actively in their learning then they are more likely to develop students who lead their own learning (Robinson, & Sebba, 2010). ICT creates an environment that is more conducive to learning than traditional settings (Chandra, 2004). The use of ICT in the classroom allows collaboration to occur.

Collaboration has also been identified as one of the 21st century skills necessary to be applied effectively by educators (Mathews, 2012; Shneiderman, 2008). This factor has become more important over the last decade and will continue to do so as the connectedness of individuals grows. According to Mathews (2012), students need collaborative skills if they are to be successful. Teachers need to ensure students experience and participate with collaborative technologies aimed at the students working together on multimedia presentations involving students around the world. Wikis and blogs can help students to be equipped with these skills and videoconferencing platforms, such as Skype, can be used to access appropriate experts directly (Bunting, 2012). Further, web-based learning allows for greater collaboration without time and distance being a limiting factor (Lili, 2013), which can also include higher level thinking skills.

Technology can be used to reach the educational aims relating to Bloom's taxonomy (Sangrà, & González-Sanmamed, 2010). According to research by Sangrà and González-Sanmamed (2010), each teacher needs to be confident in the higher level thinking processes of analysis, synthesis and evaluation. These skills are necessary for students to navigate the net and to deal with the enormous amount of information available. The internet availability and access needs to be more consistent (Robinson, & Sebba, 2010). Students need to have the confidence and skills to navigate the web safely. Teachers will need to provide their students with the opportunities to develop these skills. Differentiated programs can be designed to incorporate ICT and higher level thinking skills to give the students the skills necessary to cope with the information.

For instance, students need to be able to "make sense of what they already have access to" (Bull, Gilbert, Barwick, Hipkins, & Baker, 2010, p.28). According to Bull et al. (2010), traditionally, science typically does not emphasize these skills, but expects practising scientists to be fluent in the use of such skills. Some schools may not support this new knowledge age, but remain more geared towards the Industrial age.

Furthermore, in addition to preparing students for the global context, schools also need to prepare students for their journey to tertiary education (Bull et al., 2010). According

to Bull et al (2010), programs need to be more individualised and better cater for the needs of students. Students need to be able to work collaboratively and to use computers and digital media with the ability to work in multiple modes (Bull et al., 2010; Gilbert, 2007; Mihindo, Wachanga, & Anditi, 2017; Pietzner, 2014; Warner, 2006). The workforce needs to possess skills that are highly technical (Annetta, Cheng, & Holmes, 2010). Differentiated programs are needed which incorporate ICT and multiple modes of digital media which is a key element forming the basis for this study.

1.2 The framework for the study

Research is generally interested in initiating change by making improvements and adding knowledge to existing information, built on research based evidence which leads to a deeper understanding and validation of the issues (Smeyers, 2008). Educational research is a process where information or data may be collected either by qualitative or quantitative methods. The research process involves searching the literature to look for gaps and opportunities in the literature. This leads to questions being posed to investigate issues more deeply and in a systematic way and develop a purpose for the research (Bryman, 2012; Creswell, 2012).

A hypothesis is suggested, for some researchers, which is based on theory and known as a deductive approach. For others theory is arrived at after the research has been done and known as an inductive approach (Bryman 2012;Creswell 2012). Regardless of the type of research, the literature review is an important feature of any research. According to Bryman (2012), researchers must determine what is known about the topic and who has been involved in the research. This must be critically reviewed. Creswell (2012) describes the five steps to the process as identifying key terms, locating literature, evaluate critically the literature then organise and write a review. Creswell stated that research questions needed to be linked to the existing literature. The questions should also be clear and well formulated so the nature of the research is precise.

As stated earlier, depending on the nature of the problem and the literature review, the data collected may be qualitative or quantitative in nature. Quantitative research

involves describing or predicting trends and is often deductive, whereas qualitative research explores an issue and offers explanations. Qualitative research is often inductive (Smeyers, 2008). Data that is collected relates to a theory or a problem. It can also arise out of opportunity or personal experience (Bryman, 2012). Data collection often takes the form of interviews or surveys. Data is then analysed and triangulated to examine reliability and validity.

Social research also depends on other considerations or beliefs—epistemological (based on knowledge) or ontological (based on reality) (Bryman, 2012; Taylor, & Medina, 2013). The four main paradigms come under the two considerations. These are positivist, post-positivist, interpretivist and critical theory and are described in the next few paragraphs.

The basis of positivism is when someone looking in from the outside is completely detached from his or her own viewpoint in an objective manner so the researcher is both outside of the research and the controller (Taylor, & Medina, 2013).. The theory comes about from testing a hypothesis and collecting data by quantitative means. “Words associated with positivistic research are quantitative, scientific, experimental and traditional” (Wright, & Losekoot, 2012, p.416). This means the results are measured in a particular manner, so the research is ideally objective and can be proven. Post-positivism (critical review) is similar to positivism in that researchers detach themselves from the subjects but is different to positivism in that post-positivism researchers make inferences about human behaviour. This type of research also allows for more interactions between the researcher and the subjects (Taylor, & Medina, 2013).

Interpretivism deals with the way human action is interpreted and understood—what their words mean (Taylor, & Medina, 2013; Young, 2009). Theory is inductive and qualitative by nature. This type of analysis asks one or more of four basic questions:

1. What is the object intended to mean?
2. What could it mean to particular individuals or groups?
3. What does it mean to particular individuals or groups?
4. What is the significance to particular individuals or groups?

Critical theory is similar to interpretivist research, but focuses on unequal power relationships. The research aims at empowering the participants in the research (Taylor, & Medina, 2013). According to Taylor and Medina (2013) this type of research, when applied to education, can enable teachers to design programs that are more student centred and involve inquiry learning.

Research, generally, is done to make improvements by addressing problems (Smeyers, 2008). From there a research strategy is employed. Quantitative research is measured using numbers as statistics and is deductive in nature explaining theories. Qualitative research is all about using the words to explore the research and to offer explanations. It tends to be inductive (Mkansi, Acheampong, Qi, & Kondadi, 2012; Smeyers, 2008).

After discussing the four main paradigms in the preceding section, in the researcher's view, the appropriate research paradigm can now be chosen for the study. The researcher is looking at the effect of using differentiation in science teaching in New Zealand schools and whether this motivates students to take science to higher levels with the view of pursuing a career in a science related field. The study reported in this thesis involved a multiple method research approach that included qualitative data collected from a variety of different sources. Triangulation of the results can be corroborated or further explanations can be made based on the findings of each source. In this study, using a multiple method research approach leads to a greater understanding of the research. This is an interpretivist approach. The researcher can use a variety of different data sources to strengthen the accuracy of a study.

This research aimed to examine whether differentiated programs of work are associated with student motivation to select science as they move to higher levels of education and whether they intend to seek a science based career. This would be more in line with post-positivist research paradigm studies. However, this stance does not consider other features that may affect the results such as human action and the meaning behind the words.

An interpretivist approach reports on successful science activities where the researcher can be involved with the students and seek the meaning of an action. The researcher

in this study taught the differentiated program to a group of students and used their words to explain the meaning behind their choices. This has the advantage of providing the researcher with a way to know the students better and to be able to empathise with them to establish effective teacher-student interactions in their learning environment. Careful ethical conduct plays a big part in the research. Positivism by its very nature must be objective and does not suit this aspect of the research.

Therefore, after careful consideration the researcher decided to adopt a multiple methods approach for this study in order to provide a better understanding of the questions asked. To investigate whether students were more likely to pursue science at higher levels of education, this study used Nunley's (Nunley, 2004, 2007) differentiated programs of work as the basis of the layered activities. These activities incorporated ICT and different learning styles; as well as a variety of different instruments including a four-item attitude to science survey, in the form of the TOSRA, to gather perceptions of student attitude to science; and the Ideas in Science Survey. To provide an indication of the effectiveness of differentiated learning, data collection involved a pre- and post-administration of the questionnaires and the collection of examination results from the course.

Data involving in-depth interviews with a smaller group of 11 participants were also gathered. This information was used to generate a general explanation grounded in the views of the participants, to add further insights, and to triangulate results. The researcher needed to be immersed in the research sample environment and spent a lot of time with the participants (Humphrey, 2011) to gain a rich understanding of the interactions that were taking place. Data often involved text that needed to be deciphered by the researcher, so meanings could be uncovered and reflected upon (Young, 2009). This phase of the research involved an interpretative approach and the use of open-ended questions in a naturalistic setting.

The researcher observed the students every period during the course of the lesson over the 12-month period. Field notes were recorded whilst the students were involved with activities or directly after classes were completed. Greater clarity can be gained by reflecting on the activities once the researcher has been removed from the research site (Blöse, 2003). The notes covered discussions by the students, attitudes of the students,

problems experienced by the students and interactions between the students and the researcher.

There is a need for teachers to take part in researching to find solutions to problems as teachers who know more are able to teach better (Cochran-Smith, & Lytle, 1999). For the researcher to also be the teacher is an advantage (Kelly, 2003). Teachers are able to make sense of the research and use it in their teachings (Carlgren, 2012). Teachers bring important elements to the research that outside researchers cannot bring – ‘a depth of awareness’ as the teachers know the schools, students, colleagues and the tasks the students need to accomplish (Hubbard, 1993, p.9).

Teacher research involves teachers collecting persuasive data as teachers have an invested interest in the data being accurate (Mills, 2006). According to his research, teachers are able to develop solutions to their problems and are therefore authorities on what will or will not work in the classroom. Research done by teachers has a greater impact on teaching practice than the more traditional approach, as well as addressing questions that are more relevant to those teachers (Carlgren, 2012; Elliot, 2012). By adopting the role of teacher-researcher, teaching can be improved as the two roles are complementary which means teaching can be enriched (Xerri, 2016). Teachers can change the way they work with students through their research (Hubbard, 1993) and research becomes more meaningful to the teacher-researcher as they identify the area of focus and are able to reflect on their practice (Mills, 2006).

Teachers need to acquire new skills such as viewing the students as objects of research and finding more distanced ways of looking at what is being researched (Johansson, & Thorsten, 2017). They claim, the research process is also a lot slower and enables teachers the time to dig more deeply into the teaching problems. As described above there are many advantages for the researcher to also be the teacher involved in this study.

This section has focussed on the framework for the study discussing the main paradigms which lead to the multiple methods approach and the advantages of the teacher as the researcher involved in the study. The next section will introduce the research questions for this study and discuss the overarching aim of the study.

1.3 Research Questions

School programs in New Zealand are not currently meeting the needs of students in most New Zealand schools (Bull et al., 2010). Students, who are intending to pursue science-related careers, or need science to relate to the world around them, are not being schooled in the changes and new demands on them as individuals brought about by the needs of the 21st century. This is supported in the literature, which suggests that traditional science courses have tended to be text book based and do not allow students to apply their knowledge and skills to new situations (Bull et al., 2010). Real-world science has little representation and is often not included in everyday science lessons. Recognising that science education moves rapidly, a study done in America recently evaluated various programs in science in secondary schools (Cheung, Slavin, Lake, & Kim, 2015). This research showed that the use of textbooks, rather than online resources, in classes showed very little impact on achievement.

While textbooks are still widely used they often convey misconceptions and are slow to update when new knowledge comes available (Calado, & Bogner, 2013). The differentiated approach is different to the textbook approach in that the focus is on students' individual needs where teachers can aid students to gain new knowledge and skills as well as provide learning opportunities that can be adapted to suit (Denessen, & Douglas, 2015).

The overarching aim of this study was to provide new information about whether differentiated programs of work motivate New Zealand student's interest in science as a career. The proposed study is noteworthy because it focuses on a Layered Curriculum approach to differentiated learning. This approach, developed by Nunley (2004), presents the curriculum to the students in three layers, with each layer involving a different depth or type of thinking. Students are able to gather, apply and manipulate information as well as think critically about what they have found out. These layers were designed to cater to all children since every classroom has a variety of different children with special needs, different learning styles and different difficulties associated with learning. How the layers were developed and put together into a unit is discussed in Section 3.2.1.

This study sought to determine if this approach could enable science teachers to implement their own teaching practices to motivate students to take science to higher levels in their education pathway and investigated whether this was important to future career choices. More specifically, this study investigated whether differentiated programs of work encourage students to be motivated, show self-regulation, effect self-efficacy and high levels of personal agency, as well as allow for higher levels of thinking. To examine this aim, the following specific research questions were proposed.

1. Does the use of a Layered Curriculum approach to differentiated learning lead to improvements in student enjoyment of science lessons allowing students to become more interested, more engaged and more motivated to take science? If so, why?
2. Can the use of a Layered Curriculum approach to differentiated learning lead to enhanced student achievement?
3. Can differentiated programs of work encourage students to self-regulate allowing students to have a sense of personal agency, as well as levels of self-efficacy?
4. Does the use of differentiated programs of work encourage students to select science in subsequent years leading to a career in science and to what extent do students know about science related careers?
5. Do students perceive the choices prescribed for differentiated programs of work sufficient to match their learning styles, and do these choices reflect the types of activities the students then choose to do and what changes would they make to the activities?
6. Do various forms of differentiation allow for higher level thinking for all students as well as engagement and motivation and what do students perceive to be improvements to the A-layer section of the differentiated program?
7. Do differentiated programs of work encourage student aspirations for their assessment level?

1.4 Preamble

This research aimed to investigate a means to motivate students in this science class, and classes like this one in other locations in New Zealand. It was hoped that, in doing so, it would lead to their eventual desire to consider the pursuit of a career in science, or at the very least self-select science based subjects to a greater degree when given the choice to opt out of science. The intervention drew from Nunley's differentiated programs of work, where individuals can be catered for (Nunley, 2004, 2007). The researcher was also interested in using ICT, as well as Bloom's Taxonomy (Krathwohl, 2002) and Gardner's Multiple Intelligences (Gardner, 1993) and sought to incorporate these ideas into a differentiated program of work that might better cater for the students' needs.

1.4.1 Trialling an Idea

A differentiated unit was produced on the topic of acids and bases to trial with 24 Year 10 students. See Appendix A, for an example of a differentiated unit on bonding. The intervention involved teaching a differentiated unit of work where the students could choose the activities they wanted to pursue. Details of the production of the unit can be found in Section 3.2.1. The students could work either individually or in small groups that were self-selected.

Data was collected from the students on the first unit in the form of feedback surveys using the Differentiated Unit Survey (Appendix B). These surveys showed that the students were generally enthusiastic about the unit and liked the points scheme. They also liked to be able to work in groups for some of the activities. They did think some of the activities were not worth enough points and there was possibly too much choice. None of the students liked the lectures. Subsequent units were altered accordingly, because of the student feedback.

The trial group of 24 students then went on to participate in the next unit while three more classes of 35 students started the first unit. By the time this second group started their second unit 11 more students had joined the trial classes. All students apart from these 11 completed five differentiated units. As the students completed the various

units they were asked to complete a survey (see Appendix B), as part of the data collection, giving further feedback on the units and what students thought of them. Based on their responses the researcher also adjusted the survey form to get better feedback. A number of students were still finding the workload difficult so more class time was provided to work on the activities. The activities become more a part of the normal classroom work rather than homework. This suited the students better as a lot of them have numerous after school commitments plus a lot of homework from other subjects. The activities were used to assess what the students had learned as well as provide them with study notes in any format they chose.

1.4.2 The intervention

In total, 70 students were involved in the intervention. These students were taught a differentiated program of work based on Nunley's Layered Curriculum approach over a 12 month period (Nunley, 2004, 2007). The participating students were scheduled into the classes based on the timetable and were classes that the researcher was teaching. These intact classes consisted of two Year Nine classes and three Year 10 classes with all 70 students observed by the researcher throughout the course of the year. All students received four periods of science incorporating differentiated programs of work each week. Each period was 50 minutes in duration.

As the researcher used their different learning styles, based on the students own Multiple Intelligences Profile (see Section 1.4.2.1), to cater to their individual needs she noted that different students learned at different rates. The amount of time needed for each intervention, varied between four to six weeks. Fifty-nine of the 70 students received five interventions so, in the interests of equity and ethical behaviour and research conduct, the findings were included for these 59 students from the Differentiated Unit Survey. The other 11 were involved in four of the five differentiated units. Whilst their findings were not included from the differentiated units, their results were included from the other surveys, achievement data and interview data. Based on the researcher's 20 plus years of experience, it was felt that these students still had worthwhile information to contribute.

Differentiated units (see Appendix A) were produced based on the Multiple Intelligences profiles (see Section 1.4.2.1) and also using ideas from Nunley's (Nunley, 2004, 2007) differentiated programs of work and her website (Nunley, n.d.) as the basis of the layered activities which incorporated ICT; Gardner's Multiple Intelligences; and Bloom's taxonomy (Krathwohl, 2002). This program came about when Nunley wanted to help educate all of her students from a low socio-economic group. The differentiated programs were layered to offer higher levels of thinking and incorporated different learning styles. A point system was used as a gauge to assess how well the students had achieved in each unit and a way of keeping track of the types of activities they had chosen.

1.4.2.1 Multiple Intelligences profile

Each of the 70 students completed a Multiple Intelligences profile before the start of the intervention. The Multiple Intelligences profile had two distinct purposes. Firstly, the profile was used to determine the favoured learning styles of the students before the study to aid with the design of the activities. Secondly, to determine if the students chose activities that related to their learning styles during the five differentiated units (Research Question 5). Including an assessment of the learning styles allowed the students to determine how they best learned and was used later to further corroborate their views.

The differentiated units produced also incorporated Gardner's Multiple Intelligences into the activities. Howard Gardner proposed that there were seven intelligences not just one (Gardner, 1993; McGrath, & Noble, 1995; Pfeiffer, 2011). This model has been significant in education as teachers now will look at the student in relation to all seven intelligences and what their various strengths and weaknesses are based on various Intelligences questionnaires. The seven intelligences put forward by Gardner (Gardner, 1993) were: Verbal-linguistic Intelligence, Logical-mathematical Intelligence, Visual-spatial Intelligence, Bodily-kinaesthetic Intelligence, Musical Intelligence, Interpersonal Intelligence and Intrapersonal Intelligence. These intelligences are often simplified to word, logic and maths, space and vision, body, music, people and self (McGrath, & Noble, 1995). Later he introduced the idea of two more intelligences: Naturalist Intelligence and Existential Intelligence (Gardner, & McConaghy, 2000). Naturalist Intelligence for children who love the great outdoors,

including fieldtrips and Existential Intelligence for children who look at where people stand in the scheme of things, as a whole picture of their existence (Gardner, n.d.).

Some researchers disagree with Gardner's Multiple Intelligences theory, stating there has not been enough research, based on experimentation and observation, done to support the theory (Visser, Ashton, & Vernon, 2006; Waterhouse, 2006). According to Visser, Ashton, and Vernon (2006) and Waterhouse (2006) it is too early to include the use of Multiple Intelligence in the curriculum. Also stated was that, "Multiple Intelligences theory does not provide any new information beyond that already contributed by hierarchical models of ability" (Visser, Ashton, & Vernon, 2006, p.501.)

Despite these attitudes, Gardner's position on Multiple Intelligences still holds today (Gardner, 2017). He believes "The theory of MI's seeks to describe and encompass the range of human cognitive capacities" (Gardner, 2017, p.1) and by "challenging the concept of general intelligences, we can apply a Multiple Intelligences perspective that may prove a more useful approach to cognitive differences within and across species" (Gardner, 2017, p.1).

These paragraphs have described the work of Gardner. The following paragraph describes how Nunley has been influenced by Gardner's thinking producing the view that all children deserve a special education. From there it goes on to show how this idea was developed.

Prior to the intervention, the profile, based on Gardner's Multiple Intelligences (Gardner, 1993) was generated to determine the individual learning styles of the students. This was done to demonstrate the needs of the students beforehand to see the way in which these students engaged with their learning in order to determine the design of the units. The profile included 10 learning style focussed statements for each intelligence. Each student rated themselves out of 10 for each of the seven learning styles based on the learning style focussed statements. All students had more than one favoured learning style.

The values were then grouped according to the five scales allotted by the researcher. The first scale was a very low scale, which meant that the students had given an overall rating of zero, one or two for that particular learning style. The second scale, a moderately low scale was given if the students had scored three or four. The third scale, a moderate scale was given if students rated the learning style as a five or six. The fourth scale, a moderately high scale was assigned if students scored seven or eight. The last scale, a very high scale was allocated to those students who showed a strong affinity for that particular learning style by scoring a nine, or 10. The scale system was done to group the learning styles into more manageable groupings.

The profiles showed that musical, kinaesthetic, intrapersonal and interpersonal learning styles were popular learning styles with logical, verbal and visual being the least preferred. In spite of these preferred choices, equal numbers also disliked musical and kinaesthetic as a learning style. Activities were produced to cater for all the learning styles. For an example of a differentiated unit on bonding, see Appendix A. A copy of the Multiple Intelligence profile used in this study can be found in Appendix C.

1.4.2.2 Bloom's Taxonomy

Another model, developed by Bloom, (Krathwohl, 2002) involved six levels of thinking. These levels are the knowledge level, the comprehension level, the application level, the analysis level, the synthesis level and the evaluation level. The levels involve remembering, understanding, applying, analysing, thinking creatively and then evaluate critically (McGrath, & Noble, 1995). A teacher's role is to teach students to think, which could be done through Bloom's six thinking levels (Wineburg, & Schneider, 2010). The six levels of thinking were incorporated into each of the five differentiated units to support higher level thinking by the students.

This chapter has introduced the research and the research questions involved in the study. An idea was trialled followed by a description of the intervention, which included the Multiple Intelligences profile, as well as Bloom's Taxonomy and how they were incorporated into the differentiated units. The next chapter presents the literature review and discusses some of the problems faced globally regarding the

number of students taking science to higher levels. It also presents literature regarding secondary students disengaging from science related pathways and careers.

Chapter 2

Literature Review

2.1 Introduction

This chapter presents the literature review for this thesis. The review starts by exploring the numbers of students declining in science education (Section 2.2) as this is often a concern in New Zealand schools and is a key factor for this study. Then the possible reasons behind the low enrolment rate (Section 2.3), the gap amongst gender and minorities in science as well as students of special needs is presented (Section 2.4). Data, on science in New Zealand schools, from various international and local assessment programs are included in the achievement section of the review (Section 2.5). Types of engagement and how engaged students are in studying science in New Zealand schools, motivation and the importance of goals (Section 2.6). Self-regulation, self-efficacy and personal agency are defined and discussed (Section 2.7). The review continues by discussing differentiated classrooms as this is the basis of the thesis (Section 2.8). The uses of ICT in schools and some of the problems associated with ICT including skills needed by students and teachers are presented along with how some of these problems may be addressed, from the literature (Section 2.9). Various learning style theories including Gardner's Multiple Intelligences are described (Section 2.10). The literature review concludes by exploring the importance of higher level thinking skills and Bloom's taxonomy in relation to this study (Section 2.11).

2.2 Numbers declining in science education

This section will explore the issue of student numbers declining in science education in New Zealand and globally as this is an area of particular interest to the researcher and this study. The role and aims of education are discussed. The section reports on why students are needed to pursue science.

Education plays a vital role in any nation and in those countries where sound educational practices are not present it has been shown that the quality of education diminishes (Akomolafe, Ogunmakin, & Fasooto, 2013; Hartwell, 2014). A major purpose of education is to provide students with the knowledge, skills and

understanding to pursue a particular career or skill that will enable them contribute to economic development and growth (Biesta, 2009; Bolstad et al., 2013; Krotz, 2015). According to Biesta (2009), a second important function of education is to enable participants to become active in a society in relation to culture and religious traditions. A key aim of secondary education therefore, is to prepare students for higher education and the role that they may play in society (Akomolafe et al., 2013; Bull, 2015). “The ultimate goal of education is for students to develop their skills in schools, achieve their full potential and attain success in life” (Hotulainen, Mononen, & Aunio, 2016, p.3).

Science is an important pre-requisite for many careers, however, there is evidence that disengagement from science education is an international problem (Kierner, Gröschner, Pehmer, & Seidel, 2015; Laine, Nygren, Dirin, & Suk, 2016; Pllana, Huber, Hrdlicka, Mettouris, Veber, Ocsovszky, & Smith, 2016; Vrtič, & Šorgo, 2016). The numbers taking physics and chemistry in the United Kingdom between 1990 and 2008 fell from 49 to 26 percent, respectively (Boe, Henriksen, Lyons, & Schreiner, 2011). Numbers are still declining today (Gilbert, & Justi, 2016). Research done in Ireland also noted the low numbers taking science (Regan, & Elaine, 2009).

Declines have also been shown in various universities around the world (Boe et al., 2011). For example, numbers enrolling in *Science, Technology, Engineering and Mathematics* (STEM) degrees in America are 17 percent down in comparison to other degrees (Rogers-Chapman, 2014). This is well down compared to other countries. There will not be enough students studying STEM subjects to fill the positions in the future (Bottia, Stearns, Mickelson, Moller, & Valentino, 2015). STEM high schools have been built and are designed to increase STEM majors and prepare students for a career in STEM.

A similar problem is found in the United Kingdom with the lack of students enrolling in degree courses or apprenticeships that are STEM related (Berressem, 2011). STEM industries contribute 68 billion pounds to the United Kingdom economy and to one third of exports in the United Kingdom. Berressem predicted that 40,000 key workers in the pharmaceuticals industry will be needed Increasingly, jobs will require a

knowledge of and ability to apply STEM based skills and knowledge (Committee on Highly Successful Schools or Programs in, 2010; Xie, Fang, & Shauman, 2015).

Numbers enrolling and completing science degrees have been decreasing both in Australian Universities and overseas which means the numbers taking science related careers are also diminishing (Potvin, & Hasni, 2014; Zadnik, & Yeo, 2001). As with other countries around the world, enrolment in science subjects in Australia, once the subject was not compulsory, has declined from 79 percent in 2000 to 55 percent in 2005 (Boon, 2012). Other studies have also reported similar findings, showing a decline in the number of students taking science-related studies (Boe et al., 2011; Hine, 2016; Kenny, Seen, & Purser, 2008; Mulvaney, 2016; Ross, & Poronnik, 2016; Tytler, 2007; Tytler, Osborne, Williams, Tytler, & Cripps Clark, 2008).

In Australia, a report by Tytler (2007) showed, the government and educators showed the need to increase the number of science professionals to meet the need to produce citizens that are literate and positive towards science. A later study in Australia also showed a lack of future scientists, understanding about scientific principles and the ability to make informed decisions (Lyons, & Quinn, 2010). Research also indicates that students' interest in pursuing science is decreasing globally (Hassan, 2011). Public literacy in science generally continues to still be lacking today as in previous years (Crowther, McFadden, Fleming, & Davis, 2016).

Similarly, in New Zealand, students with a knowledge of and interest in science are needed to increase the number of science professionals available (Hipkins, & Bolstad, 2005). New Zealand needs a population that is literate in science to ensure informed participation in science-related debates and issues (Bull et al., 2010; Iosr, & Smith, 2014). There are, according to Bull et al. (2010), three main aims for New Zealand students in taking science at school. They are; career purposes; an understanding of how the world operates: and development of skills in scientific thinking.

In 2005 the number of students in New Zealand who were choosing a tertiary education, with the aim of taking up science careers, continued to decrease (Hipkins, & Bolstad, 2005). Since this study, further research has confirmed the downward trend continues once science is no longer compulsory (Bull et al., 2010; Hipkins, Roberts,

Bolstad, & Ferral, 2006). The Skills Insight Tool of the New Zealand Department of Labour predicts that there will not be enough trained people in science to meet the demands of science based occupations in New Zealand in coming years (Ministry of Business, n.d.). School students often view science as difficult and not relevant (Bull et al., 2010). A wider range of students, other than just the top one percent of high academic achievers, are needed for the workforce (Ing, & Nylund-Gibson, 2013) and attitudes, interest and motivation in science are important factors in students choosing STEM related careers.

As this section has stated, a key issue faced both in New Zealand and internationally is that we are not producing enough scientists for our needs both now and in the future (Christensen, Knezek, & Tyler-Wood, 2014; Jahn, & Myers, 2014; Tytler, 2007). This study aims to provide new information about whether differentiated programs of work motivate students in New Zealand with the aim of producing students that will be interested in science as a career. The next section will discuss the possible reasons for the decline in interest in science.

2.3 Reasons for low enrolment rate

The low enrolment rates experienced around the world are of concern and past studies have examined why this might be the case. This section reviews research that has examined factors related to low enrolment rates. In particular, this section examines students' attitudes towards science (Section 2.3.1) and the lack of good science teachers (Section 2.3.2).

2.3.1 Attitudes to science from the student perspective

Numerous past studies have indicated that students have formed negative attitudes toward science by the middle years of schooling and that these negative attitudes increase throughout secondary school (Boe et al., 2011; George, 2000; Gibbs, & Poskitt, 2010; Lowe, 2004; Tytler, Osborne, Williams, Tytler, & Cripps Clark, 2008). According to educators, students still hold these poor attitudes today (Lee, Haye, Seitz, Distefano, & O'Connor, 2016). This section will examine the reasons for the negative attitudes from the perspective of the students.

These negative attitudes are linked to many different reasons. For example, one study cited: a lack of high levels of science at primary level; poor professional development opportunities for science teachers; low numbers of teachers' college students entering teaching; and schools not offering the full range of science subjects (Regan, & Elaine, 2009). Other studies have also suggested that these poor attitudes might be related to: negative school experiences; difficulty of the subject; the subject being uninteresting and not enjoyable; learning environments being unsuitable; and the influence of teachers, parents and peers (Boe et al., 2011; George, 2000; Gibbs, & Poskitt, 2010; Lowe, 2004; Regan, & Elaine, 2009). The decrease in students choosing to take science may also stem from students not being engaged in science at secondary school (Hipkins, & Bolstad, 2005; Regan, & Elaine, 2009). They stated that students were losing interest in science so were not able to take science at university level.

Students consider science irrelevant so educators need to make science more relevant for the students (Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013). According to their research it is not clear on what making science relevant really means as there are many stakeholders including policy-makers, scientists, people in industry, as well as society in general who each have their own ideas. Four factors have been shown to influence the attitudes of the students: the students' parental attitudes, their own experiences, their views towards scientists and leisure interest in science (DeWitt et al., 2011).

Firstly, parental views have been found to predict children's career choice (Tytler, 2007). If parents perceive science as being irrelevant to the needs of their children then students are less likely to enrol in these subjects (Boon, 2012). Similar results were found in America where the attitudes of parents, as well as teachers and friends, influenced student attitudes toward STEM subjects (Rice, Barth, Guadagno, Smith, & McCallum, 2013). According to their research, those students who felt that they had great social support showed attitudes towards science that were more positive. As such, parents and teachers influenced student's subject choice both positively and negatively and students stated that the adults in their lives were not strong advocates for studying science (Aschbacher, Ing, & Tsai, 2013). Students show better learning outcomes and

better achievement levels when parents are positively involved in students learning (Ellis, Lock, & Lummis, 2015).

Secondly, research literature has indicated that science courses are not selected as often when they become optional; that is, if students have a negative attitude towards that subject then they will not enrol in it when given the choice (Simpson, & Steve, 1990). Conversely, if students show a positive attitude towards science then they are more likely to take the subject further.

Research has also shown that the science content taught to students might be affecting the students' attitudes. That is, the science taught may not be appropriate or relevant for the majority of the students (Simpson, & Oliver, 1990). For example, the *Relevance of Science* (R.O.S.E) Education project found that, for many students, science lacked relevance resulting in disengagement and a lack of motivation to pursue science to higher levels (Sjøberg, & Schreiner, 2005). Numerous other researchers support the view that some students find science to be irrelevant and uninteresting (Boe et al., 2011; Chandra, 2004; Chandra, & Fisher, 2009; Gibbs, & Poskitt, 2010; Gilbert, & Justi, 2016). In some cases, students found science to be generally important, but not a meaningful experience for them (Lyons, 2006). Personal engagement is also a factor, which affects whether students choose to enrol in science or not (Hipkins, & Vaughan, 2002).

Schools in New Zealand are generally state owned and students are taught a nationally curriculum (New Zealand Qualifications Authority, n.d.). Students in New Zealand sit examinations in NCEA (National Certificate of Educational Assessment). Some schools are privately owned and offer an alternative curriculum (e.g., Cambridge International Examinations). Teachers are required to teach the curriculum, but are able to make decisions on how this is delivered in accordance with individual school policy. Decisions on resources are often made at the departmental level.

Typical resources for a high school science classroom are the textbook and laboratories, the syllabi and the available supplies with the teacher determining what the design of the school science experience will look like, often being more based on traditional methods (Bull et al., 2010). Traditional methods often involve the use of a

textbook, so not only is science perceived to be difficult by the students, but science teachers express serious concern for the textbooks being too difficult to read (Coxhead, Stevens, & Tinkle, 2010; Walker, 2011). As an observation from the researcher, where teachers are teaching out of their areas of expertise, they may also rely on these texts too heavily to the exclusion of other more up to date or relevant resources. One of the reasons that textbooks may be difficult to read is that many contain too many unknown words, for students and sometimes teachers. Teachers do; however, find textbooks to be useful for them as they provide support, guidance and resources (Leung, & Andrews, 2012). However, other research showed that textbooks are not useful in promoting critical thinking (Errington, & Bubna-Litic, 2015).

In addition, texts need to link information together so students do not need to infer information (Hall, Maltby, Filik, & Paterson, 2014, 2016). Research has shown that this type of casual cohesion is one of the five factors that make reading the text difficult. By using connectors, such as because, to show relationships makes the text easier for students to read and understand. Another factor that makes textbooks difficult to read in science is referential cohesion, where another word is referred to within the text by using a noun, noun phrase or pronoun. Text design is an important factor to allow students to understand better, as well as allow them to read the text faster. For example, a study involving 500 students aged 14 in New Zealand showed reading enjoyment had decreased by age 12 and writing by age 14 (Wylie, & Hipkins, 2006). So approximately one third of students did not find school engaging. One of the key findings were that engagement was most likely dependant on positive learning environments. At higher levels of education science is perceived as being more about reading than practical work (Barman, 1999).

Thirdly, students often feel they do not fit the profile of a person working as a STEM professional (Kier, 2013). This is particularly true for female and minorities and is further discussed in Section 2.4. Other research also found that the students' own views of scientists have an effect on career choice (Bennett, & Hogarth, 2009). Students often view scientists as white, 'crazy', middle aged men wearing a laboratory coat (Miller, Blessing, & Schwartz, 2006; Ruiz-Mallen, & Escalas, 2012). Students' views of scientists have been likened to Moses from the bible (Chandra, & Fisher, 2009). This

is where an older male expert, the educator, provides the knowledge that the students are expected to learn by rote.

Research from around the world, (Ebert, 2012; Kennedy, Lyons, & Quinn, 2014; Sakariyau, Taiwo, & Ajagbe, 2016) has indicated that school science is largely responsible for the low student enrolment in science subjects as students find the work boring and difficult or they are not able to connect their science classes to their lives, and they are unlikely to continue to enrol in science when given the option to exit. Another study (Aschbacher et al., 2013) showed that students were interested in science by age eight due to positive experiences and parental influences but rapidly became disinterested. Students often disengaged as it became more difficult. Negative experiences resulted in a loss of interest in science based careers so secondary school experiences played a major role in future aspirations of students towards science (Aschbacher et al., 2013). Subjects such as science and mathematics were seen to be more challenging and less enjoyable (Wylie, & Hipkins, 2006). Science was thought to be difficult to master and only suitable for the more able students (Hassan, 2011; Kenny, 2008).

According to DeWitt et al (2011), as stated earlier, the fourth factor relating to students' attitude to science was their desire to participate in science as a leisure activity. Leisure is considered to be when a person is free from work commitments and is able pursue their own activities (Antonino Manuel de Almeida, 2011). He stated that this is an important factor for everyone to have in his or her life. The *Program for the International Student Assessment (PISA)* study in 2006 showed that students in New Zealand were not participating as much as other OECD countries in leisure activities involving science (Bull et al., 2010). These attitudes towards science as a leisure activity could be contributing towards the lack in numbers enrolling in science at higher levels.

Research has shown that giving students open-ended, inquiry type activities in environmental education, focusing on experiments in the field, enabled students to pursue science as a leisure activity at home (Blum, 1981). They were more likely to grow plants at home showing an interest outside of school. Other research has shown the importance of incorporating science activities with leisure activities, when in 2009,

22 minority students in America participated in the “Reach up Program” to encourage under represented students into STEM activities (Miles, 2012). They went through a program of activities that enabled them to design an investigation around a leisure activity that they enjoyed. This was motivating for the students and allowed them to carry out the investigation with great success. These types of activities could lead to a further interest in science and perhaps to seek a career in a science related field. A further study carried out with male and female students in both Canada and Australia showed engagement in science was improved with those students who participated in extra-curricular activities involving science (Woods-McConney, Oliver, McConney, Schibeci, & Maor, 2014). These activities included watching science related programs on television or reading articles about science.

Students today are still lacking an interest in STEM subjects (Crowther et al., 2016). Programs need to be developed that will give students personal gratification in doing science with a curriculum that motivates students and is relevant to them as possible (Trumper, 2006). The latest national survey of secondary schools in New Zealand, conducted every three years, showed student motivation is still a key concern amongst teachers (Wylie, & Bonne, 2016).

This section has dealt with the problems with student attitudes to science that is an issue if New Zealand wants to retain students in science to higher levels to pursue a career in science. This study aims to investigate whether a differentiated program of work will encourage students to be more interested in studying science. The next section will discuss the issue of the lack of good science teachers that also exacerbates the problem of the lack of numbers taking science. What makes a good science teacher is also discussed.

2.3.2 The lack of good science teachers and what constitutes a good teacher

This section examines the problem of the lack of science teachers, the competencies and skills needed by a good science teacher to promote a good rapport with students as well as fostering a classroom that supports students emotionally. Research and reports from around the world indicate that there is a general shortage of people who are interested in becoming science teachers (Tobias, & Baffert, 2012; Tytler, 2007).

Not only are there shortages of science teachers entering the profession in the first place, but there is difficulty retaining them (Fetherston, & Lummis, 2012; Pister, 2007). More trained science teachers are needed as well as science technicians (Berressem, 2011). A study done in Australia reported that the decline in students taking science subjects has led to a shortage of qualified scientists and science teachers (Hassan, 2011).

In addition, studies show that teachers need to be competent in science in order to provide for their students (Montoya, 2015) and have the confidence to teach science (Kenny, Hobbs, Herbert, Chittleborough, Campbell, Jones, Gilbert, & Redman, 2014). Classrooms in the 21st Century require teachers with the ability to differentiate, so all students in the classroom can be taught (Tournaki, & Lyublinskaya, 2015). Differentiation is discussed further in Section 2.8. Teachers need adequate resources, time for planning and upskilling, suitable professional development and a positive work experience to remain in teaching. Teachers need to be treated as real professionals (Tobias, & Baffert, 2012). These types of issues could be leading to a lack of science teachers.

For teachers to be effective they need to be competent in using multimedia so they must:

1. Have a positive attitude towards technology
2. Continually research advances in technology
3. Undergo professional development
4. Be experienced in multimedia use
5. Be risk-takers and able to cope with uncertainty
6. Highly reflective
7. Willing to learn alongside their students
8. Collaborative learners
9. Use a range of multimedia
10. High levels of professional energy (Buntting, 2012)
11. Select appropriate technology
12. Problem solve (Zhao, 2003)

With advances continually occurring in technology, teachers need to be further advancing themselves to meet the requirements that the new technologies bring in to

the classroom activity (Yu, & Brandenburg, 2011). They stated that it is a huge challenge for teachers who must advance with the new technologies and gain new skills and competencies. Students need to be able to deal with a changing world and these teachers need to facilitate this by keeping up with technology.

In theory, students learn more with more effective teachers or teachers who are perceived to be effective (Benton, Cashin, & Kansas, 2012). According to Benton, Cashin, & Kansas (2012) students will rate teachers and courses based on examination results and this will determine the attitude of the student towards the teacher's effectiveness, although this does not necessarily mean the teacher is effective only perceived to be by the student. Excellent teachers will arouse student interest, encourage students to collaborate, have empathy with students, motivate students to participate and have a well-structured classroom. So teachers do have an effect on students and are very important (Gibbs, & Poskitt, 2010; Hine, 2001; Iverach, 2007; Krotz, 2015; Lyons, Quinn, Rizk, Anderson, Hubber, Kenny, Sparrow, West, & Wilson, 2012; Nolen, 2003).

Furthermore, teachers need to inspire students to take science (Regan, & Elaine, 2009). According to Regan and Elaine (2009, p.271) students can be entertained in an educational manner which can "inspire as well as inform, open up new possibilities, stimulate curiosity, move people to action and transform the way we view the world." Regan and Elaine (2009) went on to state that there is little research into applying music, video stories etc. in to science education. Differentiated programs of work can incorporate these types of multimedia activities through the choices students make in the Layered Curriculum. Students can show understanding of science and their knowledge using different learning styles when presenting their work. Teachers can also foster inquiry learning as part of the program and use formative assessment approaches to show student understanding. Formative assessments (e.g., pre-tests) can be used by teachers to differentiate students into different groups (MacDonald, 2017) so individual needs can then be catered for each student.

Moreover, a key factor for teacher and student interactions is the ability of the teacher to foster a classroom that supports students emotionally making a safe environment to work in (Reyes, Brackett, Rivers, White, & Salovey, 2012). Often referred to as a

Classroom Emotional Climate (CEC). Teachers who apply high CEC's in that classroom cater for the emotional and academic needs of students. The students' needs are achieved by choosing activities that are age-appropriate as well as promote self-expression, allowing for their different interests and viewpoints. Teachers need to have trusting relationships with their pupils (Driessen, 2015). This includes engagement, providing security, encouraging exploration and supporting their students. A learning environment includes the active interaction that occurs between learner and teacher or between the learner with other learners (So, & Brush, 2008). Students are more likely to perform if the learning environment is geared towards mastery as opposed to focussing on comparing how well they do with others in the class or how many mistakes they make (Nolen, 2003).

In addition, students cannot be highly engaged unless the learning environment is orderly, otherwise there will be students who do not behave, are disengaged and who show resistance to learning (Sullivan, Johnson, Owens, & Conway, 2014). A lot of research has been done into the important role that the learning environment has in student achievement and satisfaction in learning (Banks, 2014; Hine, 2001; Iverach, 2007; Nolen, 2003; Pickett, & Fraser, 2010; Stolarchuk, 1997; Wong, Young, & Fraser, 1997).

Students who sense that the pace of the lessons was geared to leave students behind tend to learn less (Nolen, 2003). Students who do not behave is a problem faced by many teachers and is often attributed to the fall-out rate of teachers from the profession (Sullivan et al., 2014). Some teachers are able to reorganise the learning environment if they perceive students bad behaviour is a result of a classroom that is poorly organised (Banks, 2014). In New Zealand students view the classroom learning environment to be slightly more negative than the OECD average (OECD, 2015). This is a problem that must be addressed if New Zealand wishes to retain students in science to higher levels.

This section has discussed the problems associated with retaining good science teachers and the skills that good science teachers need to engage students with the aim of keeping students interested in science. By providing, a learning environment that incorporates differentiated learning, which caters for individual needs the researcher

aims to motivate students to retain their interest in science. The next section discusses STEM subjects and careers.

2.4 Science, Technology, Engineering and Mathematics (STEM)

Enrolment rates of qualified science teachers experienced around the world are low and of concern. Studies have examined why this might be the case as discussed in the last section. Further, the skills needed by good science teachers were examined. This next section reviews research that has examined STEM subjects and careers. In particular, this section examines low representation of girls, minorities (Section 2.4.1); and special needs students (Section 2.4.2).

As mentioned earlier, one of the broad purposes for school science education is to prepare students for careers in science (Bull et al., 2010). These types of careers are often referred to as science, technology, engineering and mathematics (STEM) careers. These types of careers are what future scientists will be endeavouring to undertake.

In addition, emphasis is increasingly being placed on STEM subjects in schools today (Froschauer, 2015). Students involved in STEM need to be able to problem solve and the programs should allow for inquiry learning, go across multiple disciplines, be available to all students and give students information on STEM related careers. Students need higher level thinking skills to achieve this.

2.4.1 The gap amongst gender and with minorities

This section examines the under representation of female and minority students taking science. The possible reasons behind the lack of students in both of these areas is included. Lack of vocational guidance and attitudes towards science are also examined.

Past research has indicated that there is a gap in the numbers of students at school who are proficient in STEM-based work and this gap is even more widened in minority groups (Bottia, Stearns, Mickelson, Moller, & Valentino, 2015; Sax, Lehman, Barthelemy, & Lim, 2016; Wong, 2016; Xie et al., 2015). Three goals have been

developed to address problems related to gender differences: to increase the numbers in STEM careers, expand the workforce numbers who are STEM capable including women and minorities and lastly to increase STEM literacy for all students so all concerned can make informed decisions.

Moreover, girls and under-represented minorities may show an early interest in STEM related careers but then only small numbers pursue careers in this area (Christensen et al., 2014; Ing, & Nylund-Gibson, 2013). Inconsistency in test score results has been found between minority groups. This is especially significant between Blacks and Hispanics compared to White and Asian students (Clark, 2014). There are also gaps between results of the poor and wealthy people in areas of mathematics and science.

Another problem is retaining minority students in STEM programs (Palmer, Maramba, & Dancy Ii, 2011). Research has also indicated that females, with high abilities in both mathematics and English, will be more likely to take non-STEM careers, such as law (Wang, Eccles, & Kenny, 2013). According to this research, these students have a wider choice of careers so will tend to choose a similarly challenging, but non-STEM career. Another study has shown gaps in science literacy and engagement exist between indigenous and non-indigenous students in Australia and New Zealand (Woods-McConney, Oliver, McConney, Maor, & Schibeci, 2013). Despite the curriculum, being taught in Maori there is little evidence to support the gap closing between indigenous and non-indigenous students.

Research has also indicated that girls, even if they are interested in science, would prefer a more person-oriented major, such as biology, studied science as a precursor to medicine or else they found science boring and the scientific lifestyle uninteresting (Miller et al., 2006). They found that interest in science at high school declines, but the gaps were greater amongst girls. They have negative views on scientists and do not see the profession mixing well with raising a family. In a report produced by the Washington based American Association of University Women showed that girls exposed to negative attitudes towards science and mathematics resulted in lower achievement (Robelen, 2010). There are low numbers of women in most American universities with roles as associate professors in basic science departments and even lower numbers becoming full professors (Sweazea et al., 2013).

Further, in a report commissioned by the L'Oréal foundation with the Boston consulting group issued a press release to report their findings on girls in science internationally (Foundation, 2014, p.1). According to the Foundation (2014, p.1) 14 countries were involved in the research which showed "less than one research scientist in three is a woman" as females tend to leave the science area and only "32% of science undergraduates are women, 30% hold Master's degrees and 25% have gained doctorates." The report showed that less than three percent of women have been awarded the Nobel Prize in science since 1901 when the award first started. The percentages of women in top scientific positions ranged from six percent in Japan to 34% in Spain. They also reported that prejudice and stereotypes still exist that put young girls off science. Typical stereotypes related to science as boring, boys not liking girls who are interested in science, not wanting to be a mad scientist and men are better at science.

Another issue is that these students often do not know what STEM careers are available to them (Role Models and Work Placements, 2009). Students are not getting enough vocational guidance so they can make informed decisions on appropriate subjects (Berressem, 2011). Most had no knowledge of career options in science (Aschbacher et al., 2013).

A recent study has shown that levels of engagement are not different amongst boys and girls when they first start out at high school (Kelly, & Zhang, 2016). Levels of efficacy; however, were shown to be higher in both mathematics and science among boys compared to girls. Yet the numbers of girls and minorities taking science is still lacking in numbers today (Ceglie, & Settlage, 2016).

Students today typically like to involve themselves in a number of different leisure time activities. These include watching TV, texting, talking on a cell phone, reading, eating, drinking, designing hairstyles, hanging out with grandparents, playing video games, hanging out with friends at the mall and playing with remote control cars (Barnes, Marateo, & Ferris, 2007; Delle Fave, & Bassi, 2003; Miles, 2012). Boys are often more interested in science as they tend to be influenced by books and magazines both inside and outside of school (George, 2000). More boys were showing a greater leisure interest in science than girls were. Boys like to read about sports, science fiction

and science whereas girls tend to read magazines relating to fashion or books on non-fiction (Delle Fave, & Bassi, 2003). Even now, girls are more interested in social activities and fitting in socially (Carlone, Johnson, & Scott, 2015; Dierks, Höffler, Blankenburg, Peters, & Parchmann, (2016). Additional images of STEM professionals need to be provided for students to give positive images of, in particular, girls and minorities (Kier, 2013).

2.4.2 Special needs

All children have the right to an education (McGinnis, 2013). In America in 2001, the No Child Left Behind legislation was produced with particular focus for children with special needs. The research backing this legislation showed that these children worked better with hands-on science and group work as well as guided inquiry. Lessons that involved activities were more enjoyable than lessons taken from the textbook. They stated that students were more likely to participate and complete tasks but that it was a timely process for teachers to implement.

Students with special needs are also more likely to leave high school earlier on and not stay on until the finish of their senior years, often falling behind in subjects such as science and mathematics (Villa, 2013). These students are often in larger classes in larger schools. They do better in smaller schools, where they cannot hide. Findings have shown that these students could show improvement in academic performance by enhancing their self-efficacy beliefs (Herndon, & Bembenutty, 2017). Self-efficacy is discussed further in Section 2.7.2.

This section has discussed the gender gaps and the gaps with minorities taking science as well as the issue for special needs students. The purpose of the research is to incorporate differentiated learning that caters for individual needs with the aim to motivate all students to retain their interest in science. The next section will examine achievement in science in New Zealand by reviewing data from PISA, TIMSS and NEMP.

2.5 Achievement in science in New Zealand

Achievement is a complex idea and is different across subjects (Hattie, & Anderman, 2013). They stated that not only do attitudes affect achievement, but also the reverse is also true. Achievement can affect attitude. Academic performance is a factor that educators are very much interested in (Akomolafe et al., 2013) and often three studies are used to determine academic performance in New Zealand: PISA, TIMSS and NEMP.

Data from PISA in 2006, the Third International Mathematics and Science Study (TIMSS) in 2006 and the *New Zealand's National Education Monitoring Project* (NEMP) in 2007, provide evidence for how New Zealand students are achieving in science, their interest and whether opportunities exist for students to learn science (Bull et al., 2010). These studies showed a number of results concerning students studying science in New Zealand and these findings are examined next.

Firstly, PISA is an international assessment program that assesses and compares 15-year olds performance against other countries in the areas of reading, mathematics and science (OECD, 2013). These reports are commissioned by the OECD (Organisation for Economic Co-operation and Development) in the main industrialised countries (Bull et al., 2010; Daunfeldt, Johansson, & Halvarsson, 2015) . The 2006 results showed that in New Zealand, while the average score of students was above the mean, students were weak in chemistry and physics and there is a large group of students who do not achieve well in science (Bull et al., 2010). The study also showed that students perceived negative attitudes regarding ability and importance of science to themselves personally. The study noted that only 39% of top performers had career aspirations in science.

A further study showed that the numbers performing high levels in mathematics dropped from 21% to 15% with an increase in the number of students failing to reach the baseline standard (OECD, 2014). Between 2009 and 2012 performance in science declined, despite being above the OECD average (“New Zealand”, 2016). The 2012 results showed students slipping to 18th place in the ranking for science with a sharp drop from previous times (“NZinitiative”, 2013). The report stated that, as well as the

average results falling, the bottom students were getting further behind. Maori and Pasifika were shown to do poorly in the PISA findings (Gilbert, & Bull, 2013).

The latest 2015 PISA results showed that this slipping trend has now stabilised with the science ranking now at 12th place (“New Zealand”, 2016). The report showed socio-economic status is still a higher achievement predictor, especially for Maori and Pasifika students who scored below the OECD average in science. The problem of top performers in science has remained similar to 2012, although is still lower than before 2012 and the gap between the top and bottom 10% has increased compared with most other OECD countries.

Secondly, TIMSS examines the achievement of students from around the world in mathematics and science from primary school through to early secondary school providing data about how well students have learned various skills (Carnoy, Khavenson, & Ivanova, 2013). The third study, the *National Education Monitoring Project* (NEMP) reviews performance as students move through Years One to Six at primary school (Bull et al., 2010). Both of these studies showed a decline in content acquisition. They also both stated that Year Five students had a positive interest in science, but this attitude declined as they went through school. Both studies also showed that less time was spent on science in primary schools, than other countries, resulting in the majority of students not doing experimental work. All of these studies showed there was a strong relationship between achievement levels and socio-economic background that was much stronger than other OECD countries.

The latest TIMSS report shows the average science achievement of students in Year Nine in New Zealand has altered very little in the last 20 years with the gap between high and low achievers increasing (Caygill, Hanlar, & Singh, 2016). Chemistry remains a weaker subject, especially with the boys showing a significant decrease compared to the previous result. According to the report, compared with 2002/03, there were more students who were lower achievers in this round than in 2003.

This section has reviewed the achievement levels in New Zealand and discussed the results from various international and local assessment programs. New Zealand like many other countries shows declines in interest in science with minority groups not

achieving as well. The next section will look at engagement: the types of engagement, and trends in engagement both in New Zealand and overseas as well as motivation.

2.6 Engagement, Motivation and the importance of goals

This section will highlight the need in New Zealand literature relating to engagement of the middle Years seven to 10. The factors effecting motivation will also be reviewed, motivation will be defined for this study and the importance of goals will be included. Engagement, motivation and the importance of goals are discussed in the next section with engagement (Section 2.6.1), motivation (Section 2.6.2) and the importance of goals (Section 2.6.3).

2.6.1 Engagement

Student engagement is an important aspect to ensure achievement (Fredricks, Blumenfeld, & Paris, 2004; Reyes et al., 2012). Nevertheless, engagement is often difficult to define and often used to mean motivation. Engaged students are: students that put in a lot of effort, are persistent, use goal setting techniques and enjoy the challenge of the work involved (Christenson, Reschly, & Wylie, 2012). Disengaged students are: unresponsive, off-task, distracted and will take a long time to organise themselves (Lane, & Harris, 2015). This section examines the three types of engagement, and introduces a fourth type called agentic, then seeks to define engagement for the purposes of this study. A discussion ensues of the problems of student engagement in science.

Researchers have determined three types of student engagement. These are behavioural, emotional and cognitive (Bull et al., 2010; Fredricks et al., 2004; Hipkins, 2010; Sinatra, Heddy, & Lombardi, 2015). These forms of engagement exist on a continuum from compliance through to extrinsic factors and then onto intrinsic engagement. Students who show intrinsic motivation are able to work on their own and are self-regulated in their behaviour, show learning is valued as being worthwhile and are challenging enough to be worthy of their personal effort and attention and more likely to involve higher level thinking (Hipkins, 2010).

Firstly, behavioural engagement is when a student is motivated to seek out and find answers to questions intentionally (Sinatra et al., 2015). These students are often persistent, put a lot of effort into their work, will look as if they are engaged by making eye contact and tend to be resilient. Secondly, emotional engagement refers to how students feel towards their various subjects whether they like them or not or how they feel about school. Engagement is likely to depend on the relevance of the subject to the student. Lastly, cognitive engagement refers to how invested the student is with the work they are doing, whether they choose challenging tasks or set goals.

Further research suggests another form of engagement, agentic, defined as the “student’s constructive contribution into the flow of the instruction they receive” (Reeve, & Tseng, 2011, p.258). This could include students inquiring, suggesting or communicating their interest. Agentic engagement is important for student to have as it allows students to enhance the learning activity. They can modify and personalise the work to suit themselves. Students participating in a differentiated program of work are able to enhance their learning activities to suit themselves.

According to Reeve and Tseng (2011, p.265), there are five factors to agentic engagement, “It is proactive; intentional; it tries to enrich the learning activity; it contributes to constructive input into the planning or on-going flow of instruction; and it does not connote teacher incompetence or ineffectiveness.” Differentiated programs of work can be designed to enrich the learning activity and provide agentic engagement for students.

For the purpose of this study, engagement will be defined as follows:

A multi-faceted construct that encompasses students’ sense of belonging and connectedness to their school, teachers and peers; their sense of agency, self-efficacy and orientation to achieve within their classrooms and in their broader extra-curricular endeavours; their involvement, effort, levels of concentration and interest in subjects and learning in general; and the extent to which learning is enjoyed for its sake or seen as something that must be endured to receive a reward or avoid sanction (Gibbs, & Poskitt, 2010, p.10).

As mentioned previously, student engagement as a whole decreases during the middle years of study (Gibbs, & Poskitt, 2010). This decrease is observed both in New Zealand and overseas. Moreover, a recent study in Australia has shown similar trends in student engagement in science (Lyons, & Quinn, 2010). According to Lyons and Quinn (2010, p.4) the research showed the need for “school learning experiences to be more interesting and personally relevant” as the last two decades showed a decline in the numbers of students choosing science subjects. This study delegated the decline in numbers taking science to three factors due to more subject choice available to students. These were:

1. Student images of what scientists do in their careers. Around 2/3 of students surveyed could not see themselves working as a scientist.
2. Subject difficulty. The science subjects were perceived to be harder to do with too much effort for very little reward.
3. Engagement with science. One quarter disliked science and another third were bored.

Furthermore, in New Zealand, the Year 11 students seem generally still interested in science, but schools are failing to engage these students in their science programs. Research has shown that participation in science subjects depends on engagement (Regan, & Elaine, 2009). The PISA 2006 study confirmed similar findings in New Zealand (Boe et al., 2011) to the study described earlier by Lyons and Quinn (2010). As reported by Boe et al. (2011, p.47) the PISA 2006 results showed “90% of 15-year-old students appreciated science in general and supported scientific enquiry, but only 57% agreed that science is very relevant for them personally.” Students who are engaged in science in a positive manner tend to be more likely inclined to take up a career in science (Woods-McConney et al, 2013).

According to Gibbs and Poskitt, (2010), they suggested there was a significant gap in New Zealand literature relating to student engagement of middle Years seven to 10. This study hopes to go some way to plug that gap. The next section aims to review the factors effecting motivation and then define motivation for this study.

2.6.2 Motivation

There are five key ingredients effecting motivation (Williams, & Williams, 2011). These are the student, teacher, content, method or process and the environment. A further study determined eight factors that influence student engagement (Gibbs, & Poskitt, 2010):

1. Relationships with teacher and peers
2. Relational learning
3. Disposition to be a learner
4. Motivation and interest
5. Personal agency
6. Self-efficacy
7. Goal orientation
8. Academic self-regulation

For the purpose of this investigation, the researcher will focus particularly on factors four to eight as part of the research questions. Motivation will be considered as “the internal drive directing behaviour towards a goal, has a timely, complex and intense influence on students’ ability to complete and master their school work” (Sanchez Rivera, 2010, p.8).

Motivation can be intrinsic or extrinsic. Intrinsic motivation results from student interest and curiosity (Garon-Carrier, Boivin, Guay, Kovas, Dionne, Lemelin, & Tremblay, 2016). It is self-driven and long lasting (Sanchez Rivera, 2010). Student intrinsic interest is imperative for students to be competitive in the 21st century (Oh, Jia, Lorentson, & LaBanca, 2013). Extrinsic motivation results from seeking a reward or avoiding punishment (Gibbs, & Poskitt, 2010).

This section has discussed motivation, which features as an overarching aim of this study, whereby the effect of a differentiated program of work on student motivation with an overall aim of encouraging students to pursue a career in a science related field. The next section will discuss the importance of goals

2.6.3 The importance of goals

Goals are an important factor into student motivation (Cobern, 2005; Iverach, 2007; Marzano, 2015). Goals tend to be categorised under two broad headings – mastery and performance goals (Cobern, 2005). Students who have mastery goals are interested in becoming proficient and understanding the work further whereas students who have performance goals tend to be focussed on grades (Cobern, 2005; Pintrich, 2000).

Competitive grading systems are often used in science classrooms. Students who have high levels of both goal types will be at an advantage as they can choose their goals from either type giving students more flexibility. Students are able to improve skills and move on to more challenging goals if they perceive they have achieved satisfactory progress with their goals (Schunk, 1990). If the goals are particularly challenging and specific, this leads to students performing to higher levels (Locke, Shaw, Saari, & Latham, 1981).

This section has further discussed the importance of goals for student motivation. Differentiated programs and the relationship with student aspirations will form part of this study. The next section will discuss self-regulation, self-efficacy and personal agency.

2.7 Self-regulation, Self-efficacy and Personal agency

This section will define self-regulation (Section 2.7.1) and describe the role of self-efficacy and personal agency in self-regulation. Students with higher levels of self-efficacy will be shown to perform better and that New Zealand students are below the average in self-efficacy (Section 2.7.2). The importance of personal agency is examined (Section 2.7.3).

2.7.1 Self-regulation

For the purpose of this study, self-regulation has been defined as the ability that students have to monitor their own behaviour, relating behaviour to both environmental effects and the way they have been brought up and self-reaction

(Bandura, 1991). According to Bandura (1991), self-efficacy plays a part in self-regulation as well as personal agency. People hold beliefs on themselves and what they can do, setting goals to achieve the outcomes they desire (Bandura, 2012). This in turn has an effect on career choices students aspire to (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). Students who are effective at self-regulation are able to adjust the way they do things according to the current task (Greene, Moos, & Azevedo, 2011), including persisting on tasks even if they are not enjoyed.

2.7.2 Self-efficacy

This section seeks to define self-efficacy in relation to the research questions and explain the importance of self-efficacy. Research has indicated a strong link between academic achievement, motivation and self-efficacy (Akomolafe, Ogunmakin, & Fasooto, 2013; Schunk, & Zimmerman, 2012) with self-efficacy seemingly making the most significant contribution to academic performance. Also discussed, are the results from a PISA study done in New Zealand highlighting the lack of self-efficacy amongst students in New Zealand.

Self-efficacy is a belief in oneself to have the skills to complete tasks (Cobern, 2005; Jansen, Scherer, & Schroeders, 2015; Zimmerman, Boekarts, Pintrich, & Zeidner, 2000). In other words being able to produce the outcomes desired by the student and, at the same time avoid the undesirable ones (Bandura, 1990; Thoits, 2003, 2006). Self-efficacy is also a part of being able to self-regulate. Students with higher levels of self-efficacy show higher performance and are better achievers (Bandura, 1990). People's beliefs are developed through mastery experience, social modelling, social persuasion and choice processes (Bandura, 2012). He stated, people gain self-efficacy by overcoming obstacles, seeing other similar people succeed, if they overcome anxiety and by the activities they choose which determine what they become in life. Wanting to learn is linked to self-efficacy and interest (Gibbs, & Poskitt, 2010). These students show persistence, are not intimidated and see challenges encountered as opportunities for growth and mastery when carrying out more difficult tasks (Akomolafe et al., 2013). Their research showed that self-efficacy is something that can be learned as it is based on observation and personal experience. According to Akomolafe et al (2013),

school programs should allow students to be involved in school activities and decision making.

Furthermore, research has shown that students who learn science for understanding or to be able to apply learned scientific knowledge to a different situation have a higher self-efficacy than students who learn the work for sake of an examination or test (Lin, & Tsai, 2013). Students with higher level thinking acquire deeper learning strategies in order to understand the underlying meaning of their work. This often leads to a higher self-efficacy. Unfortunately, with examination pressure, students tend to view learning science as preparing for tests rather than embracing learning strategies that are deeper and meaningful that give them a higher self-efficacy.

Moreover, in 2006 the results of the PISA study showed New Zealand students as below average in the self-efficacy dimension (Bull et al., 2010). This scale looked at students' beliefs in themselves to use science as a thinking tool. A belief in one self has been shown to have an influence on activity choice, persistence and overall effort (Cobern, 2005). Students who think they can achieve a task, show higher achievement and engagement. More challenging tasks often lead to students having low self-efficacy though they can be managed by breaking down the tasks. The value given to a task is influenced by three factors –how important the task is to the student, their personal interest in what they are doing and how useful the task is for them personally in both their daily life or for their future career (Cobern, 2005; Eccles, & Wigfield, 1995).

2.7.3 Personal agency

It has been well-documented that education in the 21st century should be moving away from the teacher directed learning known as education 1.0 and from education 2.0 where web 2.0 tools are used to a more student centred approach known as education 3.0 (Bunting, MacIntyre, Falloon, Coslett, & Forrel, 2012). This is where learners are involved in creating collaborative knowledge and therefore, taking control of their own education. According to their research, learning needs to be more personalised to cater for individual needs of the learner so they can work at their own pace. Differentiated programs, as used in this study, are designed with these features in mind. “Students

should have more control over, and take more responsibility for, their own learning” (Bevins, & Price, 2016, p.19). Personal Agency refers to the extent to which individuals are involved in their own lives (Thoits, 2003, 2006). In terms of this study, personal agency means the extent to which students have control over their own learning. Personal agency is also a part of student’s ability to self-regulate.

In addition, a science program that is orientated to the future takes into account student decision making about their own learning to a greater extent (Bunting, & Bolstad, 2013). They state that this type of learning will also involve more ties to the science community and the use of digital technologies. The importance of ICT is discussed in section 2.9.1.

Personal agency involves achieving the preferred outcome on one’s own behalf (Smith et al., 2000). These beliefs help motivate students as it is not enough to have goals and the skills to achieve those goals. Students need to believe they can achieve these goals (Ford, 1992) and these goals must be active and have a value to the individual for a student to succeed. Students should be able to “experience learning that gives more control over directions and pace” (Hipkins, 2010, p.39). Hipkins (2010, p.39) went on to say that students need to be able to “experience the chance to learn about, and shape explanations for, things that matter to the student.”

This section has defined and explained the need for personal agency. Differentiated programs are designed to give students more control over their learning. The next section reviews differentiated classrooms. Also discussed is what differentiated classrooms entail.

2.8 Differentiated classrooms

This section will examine the importance of a differentiated approach and then describe what is meant by a differentiated classroom, which includes the attributes and basic beliefs of differentiated instruction. The section further describes how differentiation can be achieved based on content, process, product and adaptability as well as identifying the barriers to differentiated instruction. A description of the

opportunity for a future orientated program, involving a more personalised approach to learning in New Zealand schools is included.

Classrooms in the 21st Century require teachers with the ability to differentiate, so all students in the classroom can be taught (Tournaki, & Lyublinskaya, 2015). A typical classroom includes students identified with special needs as well as those students who have other challenges, students for whom English is not their first language, students with attention deficient disorders and students with a variety of different learning styles (Lawrence-Brown, 2004; Nunley, 2004, 2007). Students cannot be taught as if they all learn the same way at the same pace (Lawrence-Brown, 2004). According to Lawrence-Brown (2004), whether students find the work easy or difficult all can benefit from differentiation, and this type of instruction is important to all students.

Differentiation incorporates several different theories including Gardner's theory of Multiple Intelligences and Vygotsky's Zone of Proximal Development as well as other different learning styles (Garrett, 2017; Lawrence-Brown, 2004; Morgan, 2014; Roiha, 2014; Robinson, 2017). Details of these theories can be found in Section 2.10. 'The aim of differentiation is to discover the student's actual development stage and tailor teaching so that it corresponds to their Zone of Proximal Development' (Roiha, 2014, p.3). Teachers frequently teach students who may lack basic skills, are unmotivated or are high achievers so need to provide differentiated learning to cater for all students in their classroom (Morgan, 2014).

Differentiation has two broad goals: to maximise student attainment of the general curriculum by providing support; and to provide curricula that has been adapted to both extend gifted students, and help weaker students (Lawrence-Brown, 2004). Differentiation can target a number of different aspects: goals, number of tasks, materials, the learning environment, assessment and content (Algozzine, & Anderson, 2007; MacDonald, 2016; Roiha, 2014). Teachers that include as many of these aspects as possible have better practise in the art of differentiation. For teaching to be effective, educators must start at the individual level of the student (Levi, 2008).

Differentiated classrooms are recognised as having the following attributes (Tomlinson, 1999):

1. Students learn at different rates
2. Students learn at different levels – one size does not fit all
3. They cater for different student needs
4. Assessment is on-going and diagnostic

To add to these principles are some basic beliefs (Tomlinson, 2001). Firstly, students of the same age differ in their classroom readiness and experience which has an impact on what is being taught as well as the pace needed by the student. Secondly, students work better when the work is pitched at a slightly higher level with teacher assistance. Thirdly, enhanced learning occurs when learning includes real-life experiences and opportunities for authentic learning. Lastly, learning is boosted when students are respected and valued with schools recognizing and promoting student abilities.

Later, Tomlinson added two further attributes: students compete against themselves and the programs are student centred (Tomlinson, 2014). According to Tomlinson (2014), practitioners of differentiated classrooms start where the students are at, not at the beginning of the curriculum. This is achieved by engaging students where their interests lie, allowing varying time to complete work and catering for all students with varied degrees of complexity for the work. Instruction is not mass-produced as students are recognised as individuals. Teachers in these types of classroom are ‘more in touch with their students and approach teaching more as an art than a mechanical exercise’ (Tomlinson, 2014, p.8). In addition:

Differentiation is not a recipe for teaching. It is not an instructional strategy. It is not what a teacher does when he or she has time. It is a way of thinking about teaching and learning. It is a philosophy (Tomlinson, 2000, p.1).

As teachers know their students well, learning is engaged and challenging (Wormeli, 2005).

In a differentiated classroom, all students engage and participate in their own learning whilst assuming the responsibility for their learning by making suitable choices (Algozzine, & Anderson, 2007). Problems arise when not all students are catered for. Brains release a chemical called noradrenalin, which is a hormone that affects learning (Kapusnick, & Hauslein, 2001). According to Kapusnick and Hauslein, (2001), if the

content is too difficult and the students become frustrated the hormone is released leading to withdrawal or bad behaviour. The reverse is also true for a student who finds the work too easy. Their brain releases fewer neurochemicals and the student experiences a less stimulating classroom. If differentiated instructions is implemented these two situations can be avoided.

Differentiation can be done based on content, process and product depending on the needs and strengths of the students, as well as their learning styles and interests while still having the same learning outcomes for all the students (Algozzine, & Anderson, 2007; Levi, 2008; Lewis, & Batts, 2005; MacDonald, 2016; McTighe, & Brown, 2005; Maeng, & Bell, 2015; Taylor, 2015). Differentiated content can include how the students will get the information they need for example, different level of reading books or working in different groups such as, in pairs or working by themselves (Algozzine, & Anderson, 2007). What is to be taught can be changed to suit all learners (Lewis, & Batts, 2005). Differentiating the process involves student centred classrooms based on student interests where they can work at their own pace either individually or in groups (Algozzine, & Anderson, 2007). These types of flexible groups are where students are placed in accordance to their skill level, interest or readiness (Richards, & Omdal, (2007). According to their research, these groups can be changed to suit the learner and are not set in concrete. Lastly, differentiating the product involves different assessment methods where students can use different formats to show what they know thus engaging the students by giving them more choice and greater self-efficacy so they can take ownership of their learning (Tomlinson, 2014).

Differentiation based on planning or techniques that use flexible grouping and tiered activities as well as varied products are useful to support teachers (Parsons, Dodman, & Burrowbridge, 2013). According to their research, adaptations made during instruction to meet the needs of the individual students are an important part of differentiation. Any form of assessment does often not anticipate these needs but the changes to be made are done to prevent for example, a misunderstanding of a concept. They state that teachers need to be able to monitor student progress with ongoing informal assessment and then adapt the instruction given to them. These teachers

engage in both reflection-on-learning and reflection-in-learning. Tiered instruction can be used for those learners who both struggle and for the more advanced learners (MacDonald, 2017).

Despite the limited amount of research on differentiation in science classrooms, the existing research shows the use of differentiated instruction may enhance student achievement and engagement (Maeng, & Bell, 2015). Unfortunately, barriers exist for teachers using such practices due to time, class size and lack of resources. (Robinson, 2017; Rock, Gregg, Ellis, & Gable, 2008; Tomlinson, 2014). Teachers also vary in how they perceive classroom diversity (Roiha, 2014). Schools that provide high levels of support for professional development, ensuring adequate time for planning and fostering good relationships amongst teachers show successful levels of differentiation in their schools (Maeng, & Bell, 2015).

In a recent research project commissioned by the Ministry of Education in New Zealand provided the opportunity to examine how educational research could be instrumental in the development of a learning style that was more future orientated (Bolstad, 2014). One of the themes developed was on personalised learning where the approach was built around the student. Students need to be developed to their full potential not to the same standard or level so the individual and society benefits with the individuals experiencing success and society producing a system that no longer generates failures in a system where one size fits all (Bolstad et al., 2012). This is the principle behind differentiated learning. Students need to have increased choice to motivate them (Nolen, 2003).

This section has described the importance and what a differentiated classroom looks like as well as some of the attributes and beliefs. The opportunity for a future orientated program has been described involving a more personalised approach to learning in New Zealand schools. The next section will look at the effect of using ICT in the classroom and the possible problems associating with its use.

2.9 ICT-Information, & Communications Technology

“Technology presents the opportunity to employ powerful cognitive tools that can be used by students to solve complex and authentic real world problems” (Herrington, & Kervin, 2007, p.219). Students need to be able to use a variety of technology from the start as this gives them the skills and confidence to have learner-led personalised learning (Keane, Keane, & Blicblau, 2016; Robinson, & Sebba, 2010). In particular, this section examines the importance of ICT (Section 2.9.1); the uses of ICT in the classroom (Section 2.9.2); the problems associated with using ICT in the classroom (Section 2.9.3); skills needed for effective use of ICT in the classroom (Section 2.9.4); and addressing some of the solutions to these problems (Section 2.9.5).

2.9.1 The importance of ICT in schools

Both the teacher and their students need to be competent using the internet and computer based technologies (Wylie, 2013). Schools that show innovation in integrating ICT into their teaching practices show an improvement in the teaching and learning process (Gillespie , 2014; Sangrà, & González-Sanmamed, 2010). This section reviews the importance of ICT in schools.

The NZCER recent national survey of secondary schools in New Zealand (Wylie, 2013), which is conducted every three years, provides an understanding of how things are in secondary schools. The national survey showed that teachers view the use of ICT in the classroom as beneficial to students learning. Eighty-four percent considered the use of ICT motivates students to learn, showing more knowledge and skills than traditional methods. The survey stated that ICT allows for cross-curricula learning as well as enables students to have greater control over their learning. Eighty-three percent of teachers are motivated to look at different methods for teaching while just over half viewed ICT as providing a more collaborative learning environment. Teachers agree that the use of multimedia in the classroom is beneficial to student learning (Buntting, 2012).

Furthermore, Web 2.0 is the next wave of tools for web-based communities that enables people to add information to the net (Andersen, 2007; Beeson, 2013; Mathews,

2012). The emergence of Web 2.0 tools paired with new research and assessment opportunities with online learning platforms provides new challenges for teachers (Boe et al., 2011; Reich, Murnane, & Willett, 2012). With this technology supported by good software, hardware and ultrafast broadband, opportunities for enhanced online interactions and collaboration are possible (Buntting, 2012). An increased interest in science can be achieved using the internet as students can work with a wide range of people and solve real world problems (Chiu, 1996; Lombardi, 2007; Schukajlow, & Achmetli, 2017). According to Lombardi (2007), students like to solve real-world problems as they have preference to be actively involved in the work rather than listening to a lecture.

In addition, education in the 21st century has shifted from teaching face-to-face to a more technology based learning environment where more interactive student centred multimedia learning applications are being incorporated into the classroom (Li, 2016). This type of web-based learning motivates the students and provides them with a better understanding of the work as they can interact with the information and work at their own pace. According to Li (2016), this type of technology has become necessary in the classroom as students are very familiar with, and frequently use technology in their everyday lives.

2.9.2 Uses of ICT in the classroom

The last section examined the importance of ICT for 21st learners and the need for teachers and students to attain best practise in the classroom-learning environment. The next section explores the possible uses of ICT in the classroom with the view of incorporating ICT in the differentiated programs of work.

Research shows that teachers use ICT in their classrooms with interactive white boards being the main technology for presentation purposes and the internet as a tool to support learning (Buntting, 2012; Hakverdi-Can, & Thomas, 2012). The internet is still a commonly used source for retrieving information and for simulations. Other common applications or tools include data probes, online communication and various presentation tools (Hakverdi-Can, & Thomas, 2012). Online learning environments are able to collect continuous data on student performances in working collaboratively

or for solving problems (Reich et al., 2012). Students could be assessed using real-time data as they work through current activities rather than developing more tests to measure their skills.

An example of this in an authentic learning environment is where assessment is seamlessly integrated into the activities rather than evaluating using formal tests (Herrington, & Kervin, 2007; Wong, & Yang, 2017). Students can produce online portfolios or journals. According to their research, these online portfolios can be created using web publishing software allowing the students to upload a range of multimedia including sound, video, images as well as dialogue and written information. This type of assessment often enables students to demonstrate higher order thinking.

Students can also be empowered by their use of technology in the classroom (Morris, 2010). He stated that students' sharing the knowledge and skills with others is one way that this can happen. In one school, students helped a teacher trainee troubleshoot a problem when using the interactive white board. Morris (2010) stated, teachers and pupils need to collaborate more to facilitate teaching and learning in this area. Other schools have used students as e-technicians (Robinson, & Sebba, 2010). Once technology is up and running there needs to be adequate technical support (Matusevich, 2014). To encourage and support students using their laptops one school trained up some students to help others who were experiencing technical difficulty. These e-technicians were given a special place in the library where they could help other students.

Moreover, digital technologies can be used to enhance personalised learning by enabling students and teachers to review records of progress. In the research done by Robinson and Sebba (2010) a personal online tutoring system was developed by one of the schools. This was an integrated electronic reporting and tracking system that used a learning platform to provide personalised support. This provided a variety of teaching and assessment resources. These included handouts, tests, previous attainment records, average grades, benchmarks, and attendance data that was on going for each student. This system had the advantage that all learners were highlighted who needed extra support. Other concerns such as attendance, personal issues etc. could

also be included. The system was able to be used across the whole school and provided a wealth of data. Students were able to have weekly discussions with their tutor regarding their progress. Most students preferred this system to the group tutorials although it was teacher driven rather than student led. Other schools have also used an online system of support for students (Adams et al., 2014; Chappell, Arnold, Nunnery, & Grant, 2015).

In addition, an effectiveness study on the use of computer simulations in chemistry was carried out on 718 College students from both urban and rural schools (Plass et al., 2012). The findings showed students in both areas showed improvements in their performances in chemistry. Students were both able to understand the concepts and apply the knowledge in different situations. Students with lower abilities were shown to have the highest value-added scores demonstrating the effective use of simulations on student outcomes. In another study (Lamb, & Annetta, 2013) similar findings were shown when using online laboratory simulations. The use of interactive simulations and using open-ended questions aid students to learn chemistry by providing a learner centred education system. An important part to play in this was the teacher experience and the novelty of computer use.

Innovative practice in New Zealand reported the use of ICT's where students work with scientists and are involved with peer collaboration (Buntting, 2012). Students could collect and analyse data using various technology tools such as data loggers, sensors, cameras and digital microscopes. The data can be collected both in the classroom and in the field. Students can also video conference with scientists using, for example, Skype to find out first-hand the role they play in their work (Buntting, 2012; Falloon, 2012). This can also incorporate peer collaboration in the use of a wiki space for students to post feedback. With increasing improvements in broadband, reliable software and Web 2.0 tools, the use of multimedia in classrooms will become more widespread.

For example, web based learning environments provide a safe place for students to learn new skills. New teachers often have difficulties with managing behavioural and learning issues in classrooms. Using web based learning environments these student teachers can practise these skills (Tan et al., 2010). "ClassSim" is an example of an

online simulated environment that provides genuine and relevant scenarios for pre-service teachers to explore in order to improve their teaching practise (Herrington, & Kervin, 2007; Manburg, Moore, Griffin, & Seperson, 2017).

Furthermore, online learning is popular as the Web is able to use video streaming, audio conferencing, podcasts and video casts (Andersen, 2007; Falloon, 2012). So, more people are using web based learning environments to incorporate authentic learning. YouTube videos can be used to show students how to do activities and provide expert opinions. Topics can be explained using multimedia or links provided to credible external websites. Blogs and other forums (e.g., wikis) can be used for students' discussions. A wiki is a webpage that allows users to interact with the wiki whereas a blog is an online diary (Simpson 2009). In a wiki, ideas can be shared and commented on.

These methods encourage students to go deeper than what is taught in textbooks (Tan et al., 2010). Resources are also easy to access so students can explore the topic. Students are more motivated to learn the content due to the interest generated and with it being less dull than traditionally reading books. Zadnik and Yeo (2001) showed lectures and tutorials as traditional methods of teaching science was not suitable for many students. Later research showed using ICT in teaching showed significant differences to student learning rather than improved textbooks (Cheung, Slavin, Kim, & Lake, 2017).

In Malaysia this type of learning environment has been taken on board to engage students learning by developing programs that utilise Web technology and multimedia content within the learning environment (Neo, Neo, & Tan, 2012). This allowed students to problem solve and work collaboratively. Social networks allow people to communicate with each other, exchange ideas, explore and learn. This is able to be achieved because of high speed Internet enabling the use of multimedia (Yu, & Brandenburg, 2011).

In addition, an advantage of technology over more traditional methods of learning involves students who are unable to attend school. Students can actively participate in lessons from home via the learning platform (Robinson, & Sebba, 2010). This was

demonstrated in a British school where a Year 12 student was unable to attend a lesson. They stated that she was able to submit work to the active online forum and upload a resource. Another advantage of technology is a flipped classroom which allows students to view materials at home online and then discuss the findings at school (Lai, & Hwang, 2016; Lo, & Hew, 2017).

Science teachers have access to many multimedia simulations (Plass et al., 2012). According to their research, these allow students to view and interact with processes that explain science concepts. They stated that these are visual so are beneficial over the static environment of a textbook. The simulations foster skills in scientific reasoning and problem solving.

Moreover, Herrington and Kervin (2007) described 10 principles of authentic learning. These principles included authentic contexts, collaboration and reflection (Herrington, & Kervin, 2007). The use of technology enhances these real-world practices and provides powerful tools to assist their learning. Multiple ideas can be explored with technology, allowing the range of points of view from different sources to be utilised. A learning journal can allow for reflections that could incorporate a full range of multimedia. Teachers can use tracking tools embedded within the software to review written samples. Computers should be used as a cognitive tool to allow students to be more engaged. The use of technology provides the opportunity for students to engage with tasks that could not be completed using traditional methods. These principles are still used today and students show they are engaged in learning acquiring knowledge and skills (Tan, & Neo, 2016).

The extras in Google provide a wide range of services including YouTube, Blogger and Google Scholar (Alshihri, 2017; Papastergiou, 2011; Prensky, 2010). According to Prensky (2010), YouTube videos provide a two-way communication where people post videos on line and others viewing the videos can use feedback channels to include viewer counts, ratings and text posts. He stated that Google Scholar provides a means of locating relevant articles that cite other articles, which is a valuable resource for researchers, but it does require good searching techniques. He went on to say that, there are also full text databases that can be found in libraries where information can be found which include journals and e-books all at a push of a finger.

Furthermore, teachers as well as students can produce their own websites that can aid students with their learning (Kitao, 2001; Prensky, 2010). Students can access resources from the website and post responses thus providing a more interactive learning platform. According to Prensky (2009), technology clearly plays a key role in education regardless of what educators may think about technology. Educators may have to rethink how to approach the teaching-learning process. Teachers must reflect technology proficiencies for integration to be realised.

This is starting to happen as more and more teachers today have access to their school emails from home and can also access student data (Gray, Thomas, & Lewis, 2010). According to their research, they showed that 97% of teachers in United States public schools have remote access to school emails and of this percentage, 85% access their emails. Teachers accessing student data by remote access was also high with 81% being able to do so and 61% actually accessing data at least sometimes or more often.

This section has discussed the possible uses of ICT in the classroom that can be incorporated into a differentiated program of work. The next section deals with the problems associated with ICT. The discussion also includes why technology is not utilised as widely as it could be.

2.9.3 The problems associated with using ICT in the classroom

The recent NZCER national survey showed the main issues for teachers and Principals include motivating students, student behaviour and the adequacy of ICT equipment and internet access (Wylie, 2013). The NZCER survey showed that 48% of teachers found motivating students to be an issue, 44% thought student behaviour was a problem and 54% found ICT and internet access to be inadequate. This section discusses the problems associated with using ICT in the classroom, including why both students and teachers are not utilising technology to its full potential.

Despite the benefits, ICT is not used as widely as it could be (Robinson, & Sebba, 2010; Vrasidas, 2015). It has been found that both students and teachers not using technology was due to lack of technical support with inadequate or damaged equipment, access to the internet, lack of confidence using ICT or restricted access to

technology or online resources (Robinson, & Sebba, 2010; Wylie, 2013). This was further corroborated in a report on E-in-science (Bunting, 2012). The report stated that some schools have policies that restrict students to certain sites. These sites are blocked to the students, (e.g., YouTube), thus creating further barriers to students using technology.

In addition, another study showed that barriers still exist using technology, but they tend to be secondary barriers such as knowledge and skills along with teacher attitudes and beliefs (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012). The internet has the high potential as a hypermedia system for instructional purposes but students have issues sifting through the large amounts of information available to them (Lili, 2013; Narciss, Proske, & Koerndle, 2007; Prensky, 2010).

ICT was found to also not be used as effectively as it could be with high percentages of teachers using ICT for video clips, research and presentations (Herrington, & Kervin, 2007; Morris, 2010). Less than half reported the use of multimedia work and even fewer again used blogs or wikis. Similar findings were reported in a British survey where one quarter of secondary teachers had not even heard of wikis (Davies, & Pittard, 2008). Effective use of new technologies such as Web 2.0 tools, is greatly lacking as some teachers feel threatened by students having more skills and knowledge in this area (Gillespie, 2014; Morris, 2010; Yu, & Brandenburg, 2011).

Teachers' use of technology is often higher than students as teachers like to familiarise themselves with the workings of the technology before students get to use it (Hakverdi-Can, & Thomas, 2012). Teachers' level of computer use is connected to their self-efficacy. Time is often a barrier (Bunting, 2012; Morris, 2010) with teachers having difficulty finding the time to learn new skills and use various software or hardware. Students' classroom practice may not meet student expectation as teachers are not as skilled or confident (Gillespie, 2014; Yu, & Brandenburg, 2011).

This section has reviewed the problems associated with the use of technology in the classroom. Computer use is not widely utilised in the classroom especially the Web 2.0 tools. Teachers do not have the time to upskill or may not have the attitude towards

using ICT in the classroom. The next section discusses the skills needed for effective use of ICT in the classroom.

2.9.4 Skills needed for effective use of ICT in the classroom

Teachers who are expert in the use of ICT will use a wide range of software. They will also show enthusiasm for ICT use and have their students using computers (Hakverdi-Can, & Thomas, 2012). The role and views of the teacher towards technology is crucial as their use depends on their perceptions and the trust they have in the technology and the way it can contribute to learning (Sangrà, & González-Sanmamed, 2010; Vrasidas, 2015). This section will explore the skills needed for the effective use of ICT in the classroom further.

Teachers will need to make decisions about incorporating specific ICT tools into their teaching programs (Gray et al., 2010). According to their research, decisions such as when, how and why to use them will need to be considered by teachers. They stated that this would depend on both the students and teachers' abilities in this area.

One study into computer literacy for science teachers (Ellis, & Kuerbis, 1985, 1987) produced a list of 22 competencies. These included computer awareness, applications of microcomputers in science teaching, implementing the computers, selection and evaluation of software and resources for educational computing. A later study produced 19 competencies (Tondeur et al., 2017) which included student attitudes towards ICT. Teacher beliefs play a big part in the way technology is integrated into schools (Vrasidas, 2015; Windschitl, & Sahl, 2002). Teachers when using technology change instructional practices.

Teachers who were more confident in using digital technology were more likely to use the technology for personalised learning (Hatlevik, 2017; Windschitl, & Sahl, 2002). They reported that students had some control over their learning which was a driving force increasing students' use of ICT. As this involved an element of risk in classroom management then teachers needed to be confident in their pedagogy for this to be effective (Robinson, & Sebba, 2010).

Furthermore, the classroom teacher is paramount to helping students develop important technology capabilities (Gil-Flores, Rodríguez-Santero, & Torres-Gordillo, 2017; Yu, & Brandenburg, 2011). According to their research, teachers need to be able to use technology and to know how that technology can support student learning so students can be empowered with their learning. They stated that new digital media such as social networking, blogs, wikis, YouTube and podcasting, which allows students to be engaged by providing a means through which students can communicate and exchange ideas are becoming a part of normal teaching practice. In America a survey was conducted on the use of Web 2.0 tools and found that 38% of public school teachers used blogs or wikis (Gray et al., 2010). Teachers need to make a huge effort to embrace technology. Often some may be reluctant to do so (Morris, 2010; Tallvid, 2016). According to Morris (2010), they tend to stick to areas of comfort such as word processing or internet research. There is a lack of awareness regarding social networking tools. In some cases a general lack of knowledge of educational technology tools and unfortunate beliefs about the effectiveness of technology on student learning (Guzey, 2010). Often however, when teachers first start to use technology it is the teacher who is the only one who gets to use it (Herrington, & Kervin, 2007). Usually the teacher will use technology for watching videos or for PowerPoint presentations.

Teachers showing best practice in technology have a variety of knowledge and skills in using computers, applications and tools (Yu, & Brandenburg, 2011). These include various information retrieval from the internet, data loggers, presentation tools such as PowerPoint or Prezi, email, discussion boards etc. Their research showed that good teachers also use a range of computer software simulations, spreadsheets, databases and word processors. Such teachers show positive attitudes to ICT and encourage students to use computers. They stated for teachers to teach effectively and students to learn means teachers are required to search and present the best selection of multimedia resources. Multimedia information and databases will be vital for teachers wanting to integrate ICT into their teaching.

This section examined the skills that teachers needs to incorporate ICT into their programs of work. Teachers need to be competent in using multimedia and should have a range of skills and attitudes to achieve effective use of ICT in the classroom. Teachers need to be confident so students can be empowered in their learning. The

next section addresses some of the solutions to the problems faced by teachers in using ICT effectively.

2.9.5 Addressing some of the solutions to these problems

To attain this highest level, schools must have up-to-date technology but must also “change the teaching models: the teacher’s role, issues regarding classroom organisation, the teaching and learning processes and the interaction mechanisms” (Sangrà, & González-Sanmamed, 2010, p.207). This section seeks to address some of the solutions to the problems described in Section 2.9.3.

Teachers and students are therefore under pressure to both understand and use Web 2.0 tools due to the changing nature of the work force (Mathews, 2012). In order for teachers to prepare students for the future, teachers need to understand and experience Web 2.0 tools for themselves. However, professional development in ICT is still considered high on the list of needs for teachers (Buntting, 2012; Chandra, 2004; Morris, 2010). Teachers cannot be expected to use new technologies if they do not know they exist. Specific professional development is needed to help teachers integrate the use of ICT into their programs.

Another study reported that more professional development is needed for teachers to increase their confidence and reduce fear associated with using technology (Ertmer et al., 2012). Teachers need to be willing to use their students’ assistance with technology in the implementation and planning of technology so student-centred learning can happen. Teachers need to include e-learning in their pedagogy in ways that are authentic which means both meaningful and relevant (Buntting, 2012). This will be the challenge that teachers face when incorporating multimedia into their teaching.

With the advent of Web 2.0 technology students are able to gain new skills in retrieving and evaluating information, as well as writing blogs for collaborative learning (Buntting, 2012). Assessing these skills will introduce new complexities for teachers to deal with in providing good outcomes for students. Teachers need to be involved in their own professional cluster learning networks so teachers can get involved in using

Web 2.0 tools such as Twitter e.g. Twitter4Teachers wiki where up-to-date links on science programs can be found (Ertmer et al., 2012).

Further studies into the effect of technology on student outcomes showed how the technology was used plays a part (Lei, 2010). The use of technology for general purpose or using social media had a positive effect on student outcomes, but showed subject based technology to be less so. It was reported to be difficult to measure as a lot of learning is hidden. Student performances are influenced by many factors other than just the use of technology (e.g., environment, teacher influence etc.) so dramatic changes will not necessarily happen in student performance just because technology is being used. According to Lei (2010) schools need to be certain what goals they want to achieve with students learning before technology is purchased thus providing a clear understanding for teachers and students so assessment could be done in more meaningful ways. She stated that student outcomes should include digital literacy, student behaviour and career choices not just academic achievement. According to her research traditional methods of assessment are not useful as learning is experience related and often subtle or hidden. Methods that are more suitable could be produced using performance assessment, portfolios or essays.

One way around the issue of inadequate equipment is to allow students to *Bring Your Own Device* (BYOD) to use in the classroom (e.g., MP3 players, mobile phones or iPods) (Robinson, & Sebba, 2010). This has the advantage that students are already familiar with the technology, but schools will need to be willing to provide open Internet access.

Furthermore, the trend in education today is toward Blended-learning (B-learning) (Lvarez, Martin, Fernandez-Castro, & Urretavizcaya, 2013) where lectures and tutorials are combined with computer based learning which showed increased student motivation. In blended learning ICT is used to supplement rather than replace face-to-face delivery, and also provides distinctive experiences that assist in achieving desired learning goals (Eklund, Kay, & Lynch, 2003; Motta, 2016). ICT can be used to incorporate differentiated programs into a blended learning environment.

This section has discussed the uses, problems and the benefits of using ICT in the classroom. With technology exponentially advancing at rapid rates teachers need to keep up with the advances, schools need to provide suitable hardware and training and students need to be up-to date with these changes. Learning styles will be explained in the next section with higher level thinking discussed in Section 2.11.

2.10 Learning Styles

This last section reviewed differentiated classrooms and the need for students to personalise learning. This section will discuss different models of learning styles. The section also includes how teachers' different learning styles can affect student learning.

A learning style is not in itself an ability but rather the approach in which the student is partial to (Hatami, 2013). "A learning style model classifies students according to where they fit on a number of scales pertaining to the ways they receive and process information (Felder, & Silverman, 1988, p.674). Students may often have a strong learning style preference, but learning styles are not fixed approaches of behaviour (Cheema, & Kitsantas, 2016; Hatami, 2013) They can be expanded and altered but the degree to which individuals can do this to suit a particular situation varies. Students need to be treated as individuals who learn in different ways (Pfeiffer, 2011). According to the study to treat all learners fairly means giving everyone the things they require in order to learn rather than everyone doing the same thing.

Moreover, teaching of individuals can be improved by matching up an individual's learning style to how the teacher instructs that individual (Rolfe, & Cheek, 2012). They stated learning styles are attributes of a learner that impact the way in which that person learns. Everyone has a different style; some like working in a group, others are visual or mathematical. Students are therefore able to learn in a variety of ways (Felder, & Silverman, 1988). This can involve observations, listening, learning by rote, reflecting, reasoning, making and drawing models.

The three main learning styles theories are modality styles, flexible styles and instructional styles (Rolfe, & Cheek, 2012). The first one, the modality styles theory promotes four learning styles: visual/verbal, visual/non-verbal, tactile/kinaesthetic and

auditory/verbal. According to their research a visual/verbal learner works independently and likes visual information in the form of written language such as class notes, textbooks or a written outline. A visual/non-verbal likes pictures, diagrams or flowcharts, whereas a tactile/kinaesthetic learner prefers a hands-on approach allowing them to practise what they have learnt. The last style, the auditory/verbal learner likes group discussions and lectures.

Secondly, according to Ralph and Cheek (2012) flexible styles are styles that can change slightly and have four main stages involving feeling, watching, thinking and doing. The comprehensive learner will have the ability to do all four styles but often has a preferred learning style. These learners can go between all four learning styles. Areas where students are not so good at can be improved, so learning can be maximised in all learning environments.

The third style they discussed was the instructional style. This is where learners adapt their learning to suit the context. Deep learners tend to learn because they desire to, are invested in the subject and wish to gain deeper knowledge and understanding of the work. In other words, according to Ralph and Cheek (2012) these students show intrinsic motivation. Shallow learners will learn extrinsically for a purpose such as an examination result.

Research has shown that students learning styles do not really change to any great extent (Geiger, & Pinto, 1991). There is also an association between learning styles and student well-being which can also affect academic performance (Burger, & Scholz, 2014). Students need to be able to understand, accept and appreciate others (Hoerr, 2010) and realise that students all learn in different ways.

Furthermore, intelligence has often been viewed as a single underlying general-ability characteristic which accounted for differences in the way people behave and learn (McGrath, & Noble, 1995). Howard Gardner proposed that there were seven intelligences not just one (Gardner, 1993; McGrath, & Noble, 1995; Pfeiffer, 2011). This model has been significant in education, as teachers now will look at the student in relation to all seven intelligences. Also included are their various strengths and weaknesses. The seven intelligences put forward by Gardner (Gardner, 1993) were:

Verbal-linguistic Intelligence, Logical-mathematical Intelligence, Visual-spatial Intelligence, Bodily-kinaesthetic Intelligence, Musical Intelligence, Interpersonal Intelligence and Intrapersonal Intelligence. These intelligences are often simplified to Word Intelligence, Logic and Mathematics Intelligence, Space and Vision Intelligence, Body Intelligence, Music Intelligence, People Intelligence and Self Intelligence (McGrath, & Noble, 1995). Later he introduced the idea of two more intelligences: Naturalist Intelligence and Existential Intelligence (Gardner, & McConaghy, 2000). Naturalist Intelligence for children who love the great outdoors, including fieldtrips and Existential Intelligence for children who look at where people stand in the scheme of things, as a whole picture, of their existence (Gardner, n.d.). Gardner's position on Multiple Intelligences still holds today (Gardner, 2017).

Students strong in Word Intelligence like to read, write and use language to express their ideas (Akçay, 2011; Hoerr, 2010; McGrath, & Noble, 1995). These students are likely to have a career in journalism, be an author or poet and like to public speak (Akçay, 2011). Students with an aptitude for Logic and Mathematics Intelligence like to problem solve, reason, group things together and calculate. They make good engineers, computer programmers, mathematicians and accountants. Visual learners like to draw, graph and make creative posters. They suit careers as painters, pilots and architects. Those students, who have a tendency for Body Intelligence love to play sport, perform in plays or create things. They make good dancers, athletes, surgeons and mechanics. The musical people have good pitch, like to make sounds and often play a musical instrument. These people often become singers, composers or make instruments. Students with people skills understand how others work, have empathy and make good leaders. Those with the People Intelligence will become teachers, politicians, actors, sales people or social workers. The last intelligence is Self-Intelligence. These students have an awareness of themselves, like to set goals and tend to work on their own. They may become psychologists, philosophers or therapists.

Multiple Intelligences show diversity amongst students which needs to be valued (McGrath, & Noble, 1995). Too often people will value a student's mathematics or writing ability. Those good at art, or who get along with others, without the mathematics or English ability, are considered to be not very able and to be more of a talent. Teachers often overlook musical intelligence (Armstrong, 2009). Generally,

two or three intelligences are stronger in each person even though we are endowed with all seven intelligences. These strengths have an effect on the activities that interest us in and out of school and even our future careers. Students have four main needs when it comes to learning: fun, sense of purpose, sense of freedom and self-esteem (McGrath, & Noble, 1995). The following is a quote from Gardner:

It is of the utmost importance that we recognize and nurture all of the varied human intelligences, and all of the combinations of intelligences. We are all so different largely because we all have different combinations of intelligence. If we recognise this, I think we will have at least a better chance of dealing appropriately with the many problems that we face in the world (Armstrong, 2009, p.5).

Vygotsky's Zone of Proximal Development compares the development level of a student with their potential development level given adult assistance. In other words, the distance between what the child could do by themselves and what they could achieve with adult help (Marginson, & Dang, 2017). Teachers should pitch what they teach to a slightly higher level that is too hard for the students to do by themselves but something they could achieve with the teachers help (Wass, & Golding, 2014). The potential level of the student can depend on a number of factors and include the willingness of the child to receive help and collaborate as well as when the types of help are offered (Bozhovich, 2009).

Teachers also have different ways of teaching according to their own learning styles (Felder, & Silverman, 1988). A child's learning can depend on how well the learning style of the student is compatible with the teacher. Mismatched students with teachers can result in students not doing well (Borg, & Shapiro, 1996; Felder, & Silverman, 1988). Either students need to be properly matched to teachers or teachers need to have a range of teaching modes so as to appeal to a variety of student learning styles (Lage, Platt, & Treglia, 2000). A lot of research has been done on student teacher interactions and the positive or negative effect a teacher has on a student (Koul, 2003; Martin, Veldman, & Anderson, 1980; Rickards, 1998; Stolarchuk, 1997; Weinstein, & Middlestadt, 1979). Other studies have shown a similar result (Eccles, 2006, Lee, Fraser, & Fisher, 2003, Wong, & Fraser, 2005).

This section has reviewed learning styles that are incorporated into differentiated programs of work and play a major role in the development of such programs. The next section will review higher level thinking skills and the need students have for these skills.

2.11 Higher level thinking skills

As mentioned in Section 2.4 students need higher level thinking skills to be able to problem solve to pursue careers in STEM (Bull et al., 2010). Transferable skills such as critical thinking are important skills for students to have in the 21st century as they need to be able to “analyse information critically and use it creatively and effectively to provide solutions to real world problems” (Stephenson, & Sadler-Mcknight, 2016, p.72). Students need to be both critical and creative thinkers as well life-long learners (Bolstad, 2011).

The Future-Focused Issues (FFI) project developed by NZCER to focus on concepts of sustainability, enterprise, globalisation and citizenship and how they relate to society and education, state “these complex challenges cannot be address or solved using simple problem solving” (Bolstad, 2011, p.3). According to Bolstad, (2011), different groups of people, who all need to be involved and engaged collaboratively in decision-making involving these complex issues, hold different viewpoints. Students need to have the opportunity to learn higher level thinking skills to participate in society. These opportunities rely on teachers to support students “to actively interact with knowledge: to understand, critique, manipulate, create and transform it” (Bull, & Gilbert, 2012, p.6).

Another model, developed by Bloom, (Krathwohl, 2002) involved six levels of thinking. These levels are the knowledge level, the comprehension level, the application level, the analysis level, the synthesis level and the evaluation level. The levels involve remembering, understanding, applying, analysing, thinking creatively and then evaluate critically (McGrath, & Noble, 1995). A teacher’s role is to teach students to think which could be done through Bloom’s six thinking levels (Wineburg, & Schneider, 2010). According to their research, this has often been portrayed as a pyramid placing knowledge at the bottom thus sending misinformation about the

importance of knowledge in education. Mastering new facts does not mean students will learn to think. They stated that there could be no new knowledge without new questions.

In addition, students need to have higher order thinking skills as this is viewed as an important goal in education in the modern world (Holmes, Wieman, & Bonn, 2015; Zohar, & Dori, 2003). Despite this, teachers often only consider this is important for the more-able students and that it is too difficult for lower ability ones. These teachers believe these students should be spared the frustration caused by such tasks.

Holmes, Wieman, & Bonn, (2015) and Zohar, & Dori, (2003) stated that higher level thinking skills include:

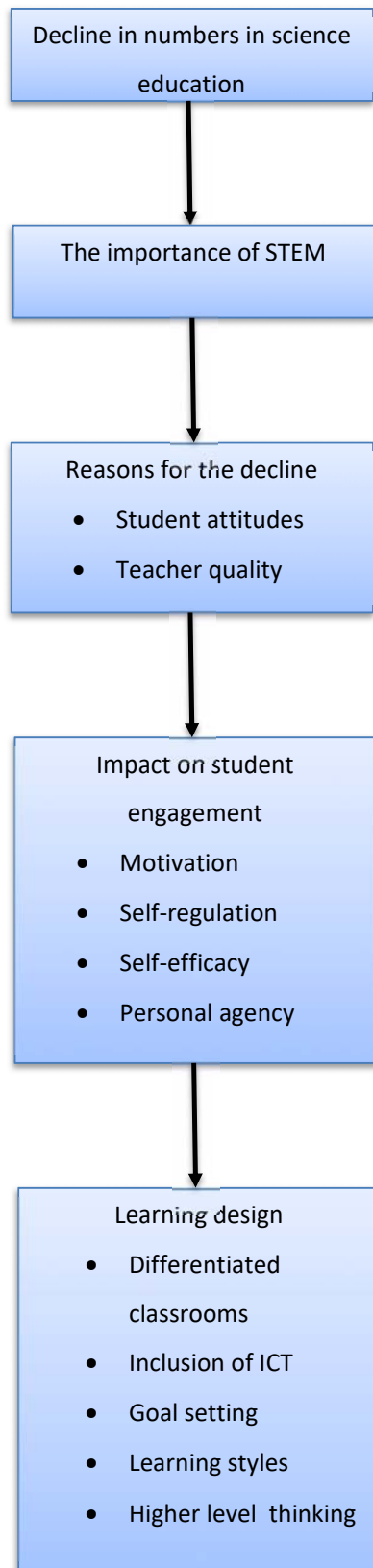
1. Debating
2. Comparing
3. Experimental design
4. Drawing conclusions
5. Problem solving

Studies done by Zohar and Dori (2003) showed that all students,—both high and low ability, showed significant gains from being assigned higher level thinking tasks. Teachers reported that students were participating in ways they had not before. Students need to be exposed and taught how to think critically and this must be a continual practise with ongoing feedback (Holmes et al., 2015). Holmes et al. (2015) suggested that students, who are exposed to this method, are more likely to continue the process on their own and into the future.

The Science Technology Society Approach encourages literacy in science and improving students' higher level thinking skills enabling students to use their education to improve their lives (Iosr, & Smitha, 2014). Science is therefore made more meaningful (Ozaktas, 2013). All students need to be able to read science articles and comment on them, problem solve and then should be able to question the quality of the data not just high ability students.

This section has discussed higher level thinking and the role it plays in 21st century education. Differentiated programs have activities incorporated into the work that include higher level thinking. One of the aims of the research is to see whether differentiation allows for higher level thinking in all students. The next section will describe the Layered Curriculum approach in more detail.

Figure 1 Conceptual framework for this study



2.12 Summary

The Layered Curriculum approach to differentiation (Nunley, 2004, 2007) was developed and produced with the view that all children deserve an education that is special. The Layered Curriculum approach incorporates learning styles and Gardner's Multiple Intelligences (Gardner, 1993) and allows for students to be exposed to higher levels of thinking using Bloom's Taxonomy (Krathwohl, 2002), as well as using ICT. This program came about when Nunley wanted to help educate all of her students from a low socio-economic group (Nunley, 2004, 2007). These layers were designed to cater to all children since every classroom has a variety of different children with special needs, different learning styles, different challenges and different difficulties associated with learning. The activities used in this research are based on the ideas produced by Nunley and are described, in more detail, later in Section 3.2.1.

The Layered Curriculum approach is basically a tiered approach where "the entire curriculum is presented to the students in three layers" (Nunley, 2004, p.13). According to Nunley (2004) she took what the students needed to know from the curriculum and divided it into three areas based on the complexity of thinking. The first layer, called the C-layer was the basic skills level for students to add to their knowledge. The middle layer was for student to apply the knowledge they learned from the basic skills and the top layer was to critically analyse to allow for higher level thinking.

The key to the method is allowing for students to have control and the easiest way of achieving this is for student to choose the activities they want to do providing students with an increased sense of personal agency. In the Layered Curriculum approach, learners need to be involved in creating collaborative knowledge and therefore, taking control of their own education (Bunting, MacIntyre, Falloon, Coslett, & Forrel, 2012). According to their research, learning needs to be more personalised to cater for individual needs of the learner so they can work at their own pace.

Students, who are also effective at self-regulation are able to adjust the way they do things according to the current task (Greene, Moos, & Azevedo, 2011). Students involved with the Layered Curriculum are able to adjust the tasks to suit their interests

with the hope of motivating them to enjoy the tasks as well as being engaged with the activities. Wanting to learn is linked to self-efficacy and interest (Gibbs, & Poskitt, 2010). These students show persistence, are not intimidated and see challenges encountered as opportunities for growth and mastery when carrying out more difficult tasks (Akomolafe et al., 2013). Their research showed that self-efficacy is something that can be learned as it is based on observation and personal experience. According to Akomolafe et al (2013), school programs should allow students to be involved in school activities and decision making.

Society needs to be able to make informed decisions regarding issues such as climate change, genetic modification and management of depleting resources with the view of finding alternative energy sources as these issues become more widely known (Bull et al., 2010). Citizens need to be able to evaluate information in a critical way and debate the issues in order to influence policy. In order for this to happen school science needs to be re-imaged and extended (Tytler, 2007). Students should be interested in learning about science so the content should be flexible and presented in multiple ways. Most importantly, science should be available to all students.

The next chapter describes the methodology used in the research. Then the chapter continues with how the research design for this study involves students being exposed to the intervention a number of times during the 12-month period. The intervention is a differentiated program of work, which enables the researcher to view how attitudes to science will change over time.

The following specific research questions were proposed:

1. Does the use of a Layered Curriculum approach to differentiated learning lead to improvements in student enjoyment of science lessons allowing students to become more interested, more engaged and more motivated to take science? If so, why?
2. Can the use of a Layered Curriculum approach to differentiated learning lead to enhanced student achievement?
3. Can differentiated programs of work encourage students to self-regulate allowing students to have a sense of personal agency, as well as levels of self-efficacy?

4. Does the use of differentiated programs of work encourage students to select science in subsequent years leading to a career in science and to what extent do students know about science related careers?
5. Do students perceive the choices prescribed for differentiated programs of work sufficient to match their learning styles, and do these choices reflect the types of activities the students then choose to do and what changes would they make to the activities?
6. Do various forms of differentiation allow for higher level thinking for all students as well as engagement and motivation and what do students perceive to be improvements to the A-layer section of the differentiated program?
7. Do differentiated programs of work encourage student aspirations for their assessment level?

Chapter 3

Research Methods

3.1 Introduction

The overarching aim of this study was to examine whether a differentiated approach in teaching science was effective in terms of motivating students to choose science as they progress to higher levels of education and their future career aspirations. Further, this study investigated whether teaching students in a differentiated science course would improve their attitude to science and level of thinking. This chapter describes the participants (Section 3.2), the research design (Section 3.3), the instruments (Section 3.4), data analysis (Section 3.5) and ethical considerations (Section 3.6). The following table (Table 3.1) is an advanced organiser for the method. The purpose of the table is to show the relationship between the activities, data collected and how this relates to the research questions (see Section 1.3).

Table 3.1 *Advanced organiser for the method*

Time-line	Research activity	Data collected	Research question
Nov	TOSRA	Attitudes to science–24 surveyed trial group	Pre-data
	Multiple Intelligences Profile	Favoured learning styles–24 surveyed	Pre-data
	Ideas in Science Survey Assessment results	Favoured activities, Career data–24 surveyed Achievement data–24 collected	1,4 2
Dec	Differentiated Unit Survey	Goals, enjoyment, activity choices, learning styles research, higher level thinking–24 surveyed	1,5,6,7
	On-going observations	Enjoyment, personal agency, self-regulation, self-efficacy, learning styles–24 students	1,3,5
	Case studies developed	On-going data throughout the year–11 students	1,3,5,6,7

Time-line	Research activity	Data collected	Research question
Feb	TOSRA	Attitudes to science–11 new surveyed trial group + 35	Pre-data
	Multiple Intelligences Profile	Favoured learning styles 11 new surveyed trail group + 35	Pre-data
	Ideas in Science Survey	Favoured activities, career data -11 new surveyed trail group + 35	1,4
	Assessment results	Achievement data–11 new surveyed trail group + 35	2
	On-going observations	Personal agency, self-regulation, self-efficacy–all 70 students all year	3
Mar	Differentiated Unit Survey (repeated 3 more times over the next 10 months for trial group and 4 more times for the second group)	Goals, enjoyment, activity choices, learning styles, research, higher level thinking–59 surveyed (not the 11 new students)	1,5,6,7
	Case studies	On-going data–11 students all year	1,3,5,6,7
Sept	Post-test Ideas in Science Survey	Favoured activities, career data-35 trial students	1,4
	Formal interview	data on all research questions-11 case studies	1,2,3,4,5,6,7
Oct	Open-ended Survey based on research questions	data on all research questions–50 students	1,2,3,4,5,6,7
Nov	Post-test Ideas in Science Survey	Favoured activities, career data-35 students (second group)	1,4
Dec	End of year exam results	Achievement data–35 students	2
Jan	End of year exam results	Achievement data–35 students (trial)	2

3.2 Participants

This section describes the participants involved in the study and has been divided into three parts to describe participants that were involved in the qualitative data collection. Participants involved in the intervention (Section 3.2.1) and those involved in the interviews and case studies (Section 3.2.2). Some of the students not participating in the case studies opted to take part in an Open-ended Survey (based on the interview questions). These students are described in Section 3.2.3.

The sample was drawn from one school located in Auckland, New Zealand. The school is a coeducational independent school offering University of Cambridge International Examinations (CIE) from Primary through to Senior College. The school offers the Cambridge International Examinations of IGCSE and A level to all students. IGCSE is a two-year course for students in Year 10 and 11 aged between 14 and 16 years. The school was selected, as the researcher was familiar with this school having taught there, making the intervention possible.

A total of 70 students were involved in the study. Of these 70 students 37 (53%) were male and 33 (47%) were female. The students were timetabled into five classes that the researcher was teaching so the classes were intact and consisted of students from Year Nine and Year 10. These intact classes consisted of two Year Nine classes consisting of 36 students out of the 70 (51%) and three Year 10 classes consisting of 34 students out of the 70 (49%) with all 70 students observed by the researcher throughout the course of the year. These students were a general representation of the population in the school. These students all volunteered to be part of the study. All 70 students participated in the Ideas in Science both pre- and post-test, as well as the TOSRA pre-test.

The Ideas in Science Survey conducted at the beginning of the intervention, used to describe the participants' attitudes towards science, showed 33 out of 70 students (47%) were taking General science, which is compulsory. The data showed one student out of 70 (1%) was taking one individual science subject, 19 out of 70 students (27%) were taking two science subjects and a further 17 out of 70 students (24%) were taking three sciences. Just under half of the students indicated they would take science as a career. These students were mainly looking at the fields of medicine, veterinary science, being a scientist or an engineer. Apart from nine students out of 70 (13%) who were not sure the rest of the students were definitely not taking science further.

Students were asked in the survey, to name at least five careers involving science. The responses showed 59 out of 70 (84%) of students were able to name at least five science careers. Those most commonly named careers were doctor and forensic

scientist, closely tied followed by chemist, biologist, physicist, science teacher, dentist, veterinarian, astronomer and scientist. Forty-one different science careers were named.

The student responses from the Ideas in Science Survey also showed 42 out of the 70 (60%) indicated that experiments would make science more interesting. Other ideas included fieldwork, using computers, group work and games but these were each liked by only one student. Two out of 70 (3%) wanted less in the way of tests, three out of 70 (4%) wanted less writing and a further two out of 70 (3%) wanted less homework.

A further eight students were involved in the intervention classes, but the data collected from these students was not included in the analysis as they either did not complete the surveys or missed too many of the intervention lessons (as they either enrolled at the school after the beginning of the intervention or left before it was completed).

3.2.1. Sample for the differentiated units

All of the 70 students involved in the intervention were given the opportunity to be involved in the data collection for the differentiated units. However, of the 70 students, 11 students missed a portion of the intervention (one of the five units). Therefore, survey data collected from these students during the intervention were not included (as these results were incomplete). This provided a sample of 59 students involved in the five Differentiated Unit Surveys. Of the 59 students 27 (46%) were female and 32 (54%) were male. These students were timetabled into five classes that the researcher was teaching so the classes were intact and consisted of students from Year Nine and Year 10. These intact classes consisted of two Year Nine classes and three Year 10 classes. Of the 59 students 32 (54%) were in Year 10 and 27 (46%) were in Year Nine and were aged 13 to 15 years old. The students were all drawn from classes that were studying to IGCSE (Cambridge International General Certificate of Secondary Education) level as these students made up part of the middle school years.

3.2.2 Sample for case studies

Of the 59 students who were involved in the intervention, 11 students from Year 10 were selected to be involved in the case studies. These 11 students were chosen to

participate in the case studies involving observations and extensive interviews. The 11 students were chosen based on gender, range of ability levels and range of attitudes towards science based on the TOSRA results as well as a range of favoured learning styles and whether they were likely to take up a career in science. The Test of Science-Related Attitudes (TOSRA), developed by Fraser (1982), was used to assess the students' attitudes towards science in order to help determine the students suitable for the case studies and was administered to all 70 students. This survey is designed to assess seven dimensions: social implications of science, normality of scientists, attitude toward scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, and career interest in science (Fraser, 1982).

In past research, the scales of the TOSRA have been found to have high internal consistency reliability. The reliability in past studies was measured at $\alpha=0.94$ for enjoyment of science lessons, $\alpha=0.91$ for leisure interest in science, $\alpha=0.91$ for career interest in science and $\alpha=0.74$ for normality of scientists (Fraser, 1982). Given the high internal consistency reliability reported in past studies, the TOSRA was considered a good instrument. Further, the TOSRA has the advantage of being able to compute a separate score for each attitude so that the attitudes can be viewed separately or comparatively.

Four dimensions of the TOSRA were identified as being relevant to the research questions and were selected to collect data in the present study, these being: normality of scientists, enjoyment of science lessons, leisure interest in science, and career interest in science (see Appendix E). Normality of scientists assessed the students' ideas on their views about scientists and whether they viewed them to be the same as everyday people. This dimension included statements such as: scientists are about as fit and healthy as other people are and scientists like sport as much as other people do. Enjoyment of science lessons assessed whether the students liked their science lessons or not and included statements such as: school should have more science lessons each week and science lessons are fun. The third dimension assessed students' leisure interest in science and included statements such as: I would like to belong to a science club and I would like to be given a science book or a piece of science equipment as a present. The last dimension, the career interest in science assessed the likelihood of the students to take on science as a future career. Statements included when I leave

school, I would like to work with people who make discoveries in science and working in a science laboratory would be an interesting way to earn a living.

For the purposes of this research, data based on the *Test of Science Related Attitudes* (TOSRA) were collected at the beginning of the course. Students were asked to circle one of the responses for each question. The responses being strongly agree, agree, uncertain, disagree and strongly disagree. This is based on a Likert type system.

A summary of students involved in the case studies is shown in Table 3.2. There were, a total of 11 students who were selected for the case studies based on the criteria indicated above.

Table 3.2 *Summary of students involved in the case studies*

Case study	Gender	Starting grade	Career before	TOSRA mean results			
				Enjoy	Leisure	Career	Normality
1	F	B	Not sure	4.0	3.0	3.9	3.1
2	M	E	No	3.8	3.2	3.9	3.2
3	F	F	No	3.1	1.2	1.8	3.3
4	M	G	No	4.1	3.7	3.2	3.3
5	F	A	Not sure	3.1	2.2	3.0	3.4
6	F	F	Yes	4.4	4.4	5.0	4.2
7	F	D	No	2.8	2.1	2.7	3.0
8	F	B	Not sure	5.0	4.3	4.7	4.1
9	M	F	No	3.4	1.8	2.1	2.4
10	M	A	Yes	3.0	2.8	2.9	3.4
11	M	E	Yes	4.7	4.4	4.0	3.5
Means for TOSRA scale whole sample				3.8	3.0	3.4	3.4

n=11

The sample consisted of six girls, ranging in ability from an A to an F grade and five boys, ranging in ability from an A to a G grade. Of the 11 students, only three had indicated they would definitely be partaking in a career in science. The mean results for the four scales: enjoyment of science, science for leisure, science as a career and

normality of scientists were taken from the 59 students involved in completing all five differentiated units.

The TOSRA results of each of these students were taken into consideration to ensure a range of attitudes of the participants in the case studies. Six of the 11 students had a mean score equal to or less than the mean score for enjoyment of science from the 59 students. Seven students had a mean score equal to or less than the mean score for science for leisure from the 59 students. Six of the 11 students had a mean score equal to or less than the mean score for science as a career from the 59 students and eight of the 11 students had a mean score equal to or less than the mean score for normality of scientists from the 59 students. All 11 students fully participated in all five differentiated programs and answered all surveys and interview questions.

3.2.2.1 Details of the case study students

This section describes the 11 students involved in the case studies providing information from the Ideas in Science Survey at the start of the intervention, achievement levels and results of the TOSRA. Case study 1 was a female student who was working at a low B level of achievement prior to the intervention starting. According to the TOSRA, she appeared to enjoy science and had a reasonable desire to pursue as a career, but science activities were not really part of her leisure time as compared with the means of the whole sample size. Case study 1 was studying two sciences to enable her to have a broad range of job opportunities. According to her Ideas in Science Survey, she was not sure if she wanted to take science as a career but if she did, it would be as a veterinarian, doctor or science researcher. Learning styles: mainly kinaesthetic, interpersonal with a leaning toward musical, and verbal.

Case study 2 was a female student who was working at a very top level of achievement—an A level. The researcher would have expected this student to show a higher enjoyment in science considering her high ability. Even her leisure activities do not involve much in the way of science. The results also seem to indicate only a mediocre likelihood of a career in science. Yet when the researcher spoke with her, Case study 2 was currently taking three sciences in case she wanted a science related career in the future. According to her Ideas in Science Survey, she was unsure if she wanted a science related career. Learning styles: mainly kinaesthetic, musical with a

leaning toward interpersonal, intrapersonal, visual, and logical. The only area she was not keen on was verbal.

Case study 3 was a female student who was working at a D level of achievement. Case study 3 showed a lower interest in science as a career, as well as a lower interest in science for leisure time. Enjoyment level of science was also very low with a slightly higher value for normality of scientists. All of these values were below the mean for the total sample, especially the enjoyment scale. She was taking two sciences at the start of the intervention as she felt she did well at them in Year 9. According to her Ideas in Science Survey, she was not wishing to pursue a career in science, as she wanted to be a criminologist or do something with athletics. Learning styles: mainly musical, kinaesthetic and interpersonal with a leaning toward intrapersonal.

Case study 4 was a female student who was working at a mid B level of achievement approximately 75%. According to the TOSRA results for Case study 4, she appeared to enjoy science and had a reasonable desire to pursue science as a career. These results were also higher than the mean results for the whole sample. She also perceived science as a leisure activity and viewed scientists as normal people. Case study 4 was taking three sciences, as she liked them. Based on her Ideas in Science Survey Ideas in Science Survey she was not sure if she wanted to take science as a career but if she did, it would be a career in medicine as a doctor. Learning styles: low in verbal and musical but moderate in the other styles.

Case study 5 was male student who was currently working at an A level of achievement. It is interesting to note his low scores for leisure and a career considering that he was a top student in science. All four scales were below the mean for the total sample. He was taking three sciences at the start of the intervention and he reflects that he was open to all possible future pathways. He wanted to get into a good university to gain knowledge that may come in useful in future life. Despite his low career scale in the TOSRA result, he indicated in his Ideas in Science Survey Ideas in Science Survey that he wanted to take science as a career option but he was not sure what it would be. Learning styles: mainly intrapersonal and verbal with a leaning toward logical and kinaesthetic.

Case study 6 was a male student who was currently working at a high E level of achievement. His results generally showed a mediocre view towards scientists as normal people and as a leisure activity with a slightly higher attitude towards science as a career and enjoyment with the subject. According to his Ideas in Science Survey Ideas in Science Survey, this student was taking three sciences before the intervention because his parents were making him take them. He wanted to be a Surveyor. Learning styles: mainly musical, interpersonal and visual with a leaning towards logical and intrapersonal.

Case study 7 was a female student who was working at an F level of achievement at the start of the intervention. It is interesting to note her TOSRA scores are high in all four scales when compared to the means of the whole sample size, considering her ability in the subject. She was taking two sciences because she finds them interesting and needs them for the job she wants in the future, although she states she is not considering a career in science. According to her Ideas in Science Survey Ideas in Science Survey, she is considering working in the field of sport or health. Therefore, she knows she needs science to do these jobs but does not consider this a science vocation. Learning styles: mainly kinaesthetic with a leaning toward interpersonal.

Case study 8 was a male student who was currently working at a G (less than 30%) level of achievement. His TOSRA results showed a relatively high level of enjoyment in science and interest in science for leisure compared with the whole sample means. Case study 8 was less likely to choose a career in science. His view of scientists also indicated a lower than average score. According to his Ideas in Science Survey Ideas in Science Survey, he indicated that he was not going to take science as a career before the intervention. This student had a history where homework was not always completed. Learning styles: extremely high on intrapersonal and visual.

Case study 9 was a female student who was working at an F level of achievement. It was interesting to note her scores from the TOSRA, for all four scales, were higher than the mean results of the whole sample considering her lower ability in the subject. The career scale had the top mark possible indicating a very high likelihood of pursuing a career in the sciences. Case study 9 was taking two sciences at the start of the intervention. According to her Ideas in Science Survey Ideas in Science Survey,

she wished to study Marine biology and so had a general interest in these subjects. She also liked experiments. She was hoping to pursue a career as a Marine Biologist. Learning styles: mainly musical and intrapersonal followed very closely by logical, interpersonal, kinaesthetic and verbal. Visual was middle of the range. This student indicated she suited all the different learning styles to at least a reasonable level.

Case study 10 was a male student who was working at an F level of achievement. The results of the TOSRA survey showed a below average enjoyment of science with a less likely chance of a career when compared to the means of the whole sample size. He did not see science as a leisure activity and he viewed scientists as not necessarily normal people. Case study 10 was taking three sciences before the intervention as he says they were interesting. According to his Ideas in Science Survey Ideas in Science Survey, he stated that he was definitely not taking science as a career. This student had shown in the past that he was very good at handing in homework. Learning styles: all areas extremely low but logical was the highest value even though it was very low.

Case study 11 was a male student who is currently working at a mid E level of achievement. Despite his low level of achievement, he had a very high level of interest in science in all of the four areas. He was currently taking all three sciences as he stated that science interested him. He indicated in the Ideas in Science Survey Ideas in Science Survey that he wanted to take science as a career but he was unsure in what capacity. Case study 11 was another student who was not very good at handing in homework based on experience. Learning styles: mainly musical, interpersonal and intrapersonal with a leaning towards logical.

3.2.2.2 In-depth interviews

The 11 case studies were involved in extensive interviews at the conclusion of the intervention. The interview questions were developed by the researcher and consisted of seven different sections, based on the seven research questions. These were broken down into 19 generally open-ended questions, the development of which followed Kvale's (2013) criteria. According to Kvale (2013) a good interview includes the following criteria: contain rich, spontaneous answers that are relevant; short questions

with long answers; and meanings are clarified, followed up and interpreted throughout the interview. Attempts were made to ensure that the questions were clear and short and involved easy to understand language. A copy of the interview questions used to guide the interviews can be found at Appendix F.

The students at the start of the interview were clearly told what the interview was about and consent was received. The interviews were conducted in accordance with Kvale (2013) and lasted approximately 30-40 minutes. Students were able to complete what they were saying and could go at their own pace and they could elaborate on any areas that needed further comment. The researcher was able to steer the students back to the situation at hand if they digressed and could clarify and extend meanings of the students' statements that the students could confirm as being correct. The interviews were transcribed within 24 hours of being conducted. The data was interpreted to triangulate responses from the earlier instruments to help generate a general explanation of how the views of the participants changed over time. The interviews were recorded by audio and stored as MP3 files that were transcribed verbatim for analysis at the end of the intervention. The data was placed into an excel spreadsheet in columns relating to each question. Themes were then generated based on the data. As each theme emerged the theme was assigned a particular colour. Every piece of data showing that theme was colour coded for ease of counting. This process was repeated until all of the data had been coded. The data was checked multiple times for accuracy.

3.2.3 Sample for Open-ended Survey

The researcher, which the 70 students could opt into, developed an Open-ended Survey (based on the interview questions). Eleven of these students were already participating in the case studies so of the remaining 59 students 50 opted to participate in the survey. The survey was done on-line and involved the interview questions used in this study. The sample consisted of 26 females (52%) and 24 males (48%) from the five classes. Of the 50 students, 19 students (38%) were from Year 10 and 31 students (62%) were from Year 9. These students completed an Open-ended Survey (based on the interview

questions) at the completion of the course. These students had all participated in at least four differentiated units.

3.2.3.1 Open-ended Survey

To provide an overview of the students' views of the differentiated units, such as likes and dislikes, changes to goals, problems encountered etc. an Open-ended Survey, based on the interview questions, was developed by the researcher. As with the interviews, the survey consisted of seven different sections, based on the seven research questions, broken down into 19 generally open-ended questions. This survey was completed on-line by the students at the end of the intervention to triangulate the findings of the other instruments. The data was placed into an excel spreadsheet in columns relating to each question. Themes were then generated based on the data. As each theme emerged it was assigned a particular colour. Every piece of data showing that theme was colour coded for ease of counting. This process was repeated until all of the data had been coded. The data was checked multiple times for accuracy.

These interviews and surveys were used to gather information to inform:

Research question 1: Does the use of a Layered Curriculum approach to differentiated learning lead to improvements in student enjoyment of science lessons allowing students to become more interested, more engaged and more motivated to take science? If so, why?

Research question 2: Can the use of a Layered Curriculum approach to differentiated learning lead to enhanced student achievement?

Research question 3: Can differentiated programs of work encourage students to self-regulate allowing students to have a sense of personal agency as well as levels of self-efficacy?

Research question 4: Is there a relationship between differentiated programs of work and subject selection in subsequent years leading to a career in science, and to what extent do students know about science related careers?

Research question 5: Do students perceive the choices prescribed for differentiated programs of work sufficient to match their learning styles, and do these choices reflect the types of activities the students then choose to do and what changes would they make to the activities?

Research question 6: Do various forms of differentiation allow for higher level thinking for all students, as well as engagement and motivation, and what do students perceive to be improvements to the A-layer section of the differentiated program?

Research question 7: Is there a relationship between differentiated programs of work and student aspirations for their assessment level?

3.3 Research Design

The approach used to conduct this study is one in which the researcher was immersed in the learning environment with the participants. The research design involves a group that can be studied over time with multiple observations being made as well as post-testing. Treatments and measures can be alternated. This is a time series design or more specifically an equivalent time series design (Creswell, 2012).

It consists of studying one group over time with the treatment alternated with a post-test measure. Post-tests can be compared or plotted to unravel patterns in the data over time. For example, in this study participants were involved in a differentiated program of work with the researcher immersed in the study. At the completion of each unit, the participants took part in a post-test survey. This series of events was repeated four more times over the course of the year. The data collected was coded and then themes were generated based on the data supplied.

The study reported in this thesis involved an interpretivist approach. As an interpretivist approach, the students were observed and extensively interviewed with the researcher working closely with the participants. This study employed a triangulated multiple methods approach as the research employed the collection of multiple qualitative data sources. The instruments used were various surveys, observations, case studies and interviews and are described in Section 3.4.

By utilising a multiple methods approach, the researcher was able to triangulate the results from each form of data collection to validate the results. Using triangulation was also used as a means of providing a greater understanding of the participant's data. According to Creswell (2012, p.259) this is done to find evidence to support a theme, ensuring the study will be accurate "as it draws on multiple sources and information."

The data was collected at different times throughout the study. Four types of data were collected before the intervention started: data on leaning styles using the Multiple Intelligences profile (see Appendix C), assessment data, data on the student ideas beforehand using the Ideas in Science Survey (see Appendix D) and the TOSRA data (see Appendix E). The Multiple Intelligence profile was to determine the favoured learning styles of the students before the intervention to aid with the creation of differentiated activities and to compare with the student responses in the Differentiated Unit Surveys to determine if students chose activities that related to their learning style (Research question 5). Assessment data was collected to provide baseline data on student achievement and other data was gathered on their ideas on science before the Intervention. Data was also collected in the form of the TOSRA. This was done “to help determine the best means for recruiting participants” (Creswell, 2012, p.545), involved in the case studies using the TOSRA and to give data on the students before the intervention on attitudes to science relating to normality of scientists, careers, enjoyment of science and science for leisure. The Ideas in Science Survey described in Section 3.3.2 was used to corroborate the views of the students at the beginning of the intervention relating to career choice from the TOSRA findings and then collected post-test. Achievement data was also collected post-test so the initial results could be compared to the results once the intervention was completed using the achievement data (Research question 2).

Data was also collected at the end of each of the five differentiated units using the Differentiated Unit Survey. The Open-ended Survey (based on the interview questions) was collected at the end of the intervention whilst observations were made throughout the study collecting data on all students. Some students were studied in more detail as case studies using various surveys, observations and interviews. During and after the five interventions the students participated in a series of post surveys using the Differentiated Unit Survey that was designed to provide data on goals, choices of activities and thinking skills. This was done to see how students’ attitudes changed over time. Further data was collected in the form of observations by the researcher, Open-ended Surveys (based on the interview questions) and case studies to add additional data and to help triangulate the responses. Based on the data collected

from the various surveys, case studies and from observations made by the researcher insights could be made regarding self-efficacy, self-regulation and personal agency.

3.3.1 Production of the units

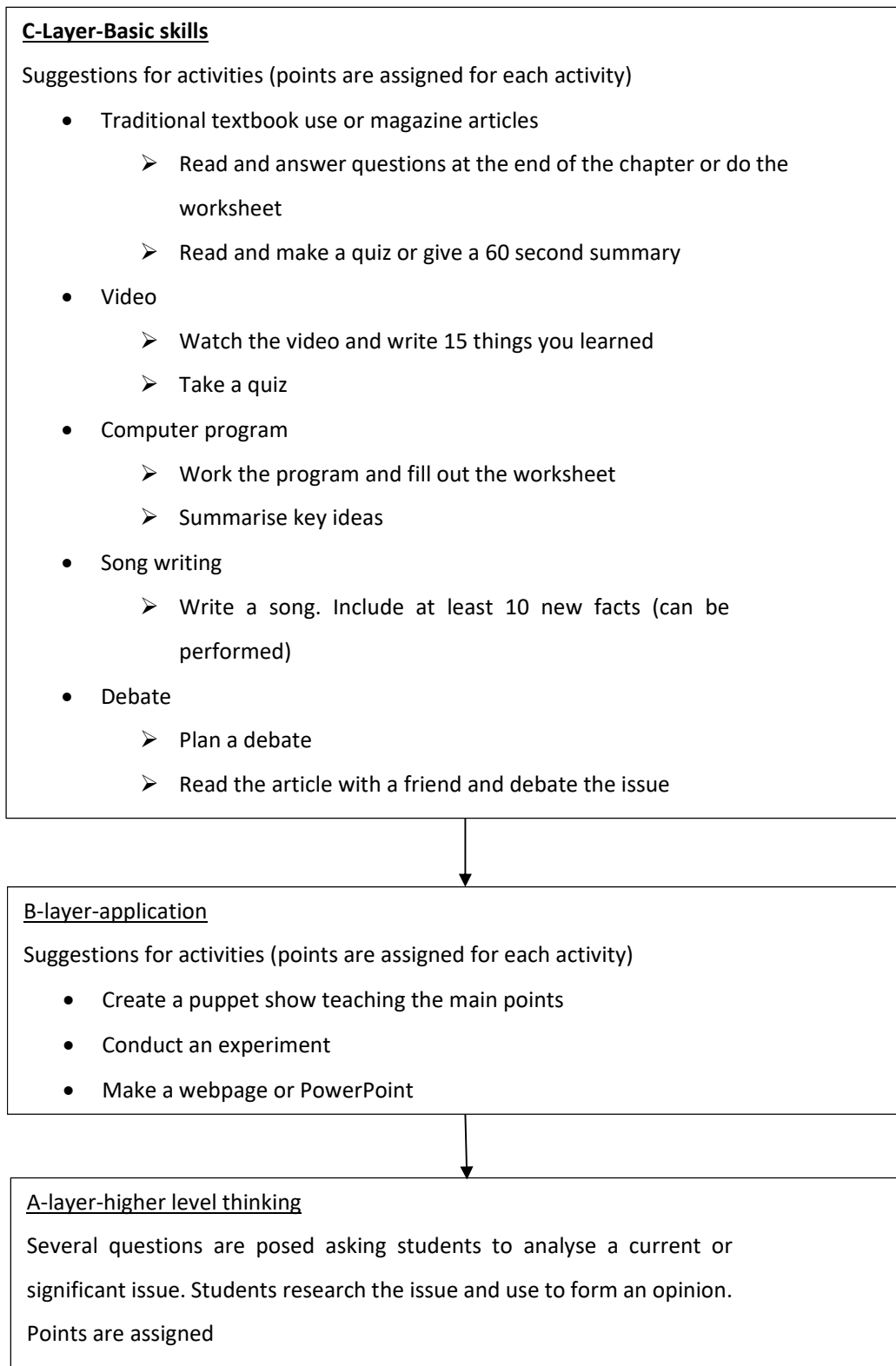
Once the Multiple Intelligences Profiles of the students were collected the units were able to be produced to ensure all of the learning styles were incorporated in the units. Ideas from Nunley's work on differentiation, Gardner's Multiple Intelligences and Bloom's Taxonomy, as well as ICT were incorporated into the units which considered the various learning styles of the students.

Each unit was separated into three layers to allow for different levels of thinking according to Bloom's Taxonomy (see Section 1.4.2.2). The layers were the C-layer, the B-layer and the A-layer with all layers incorporating ICT, Gardner's Multiple Intelligences and Bloom's Taxonomy (see Section 1.4.2.1 for details of multiple intelligences). The units also included the various learning styles of the students involved in the study.

The C-layer was the skills layer where students learned the main concepts of the topic. Students chose activities that suited their learning style or that they were interested in doing to achieve the required number of points. For example, in a unit on acids and bases the students might have chosen to do a poster on the methods of producing salts. Once they had completed the C-layer, they then went onto the B-layer where they applied what they learned from the C-layer to a different situation once again having chosen the activities they wanted to achieve this. For example, in the acids and bases unit they may have chosen to design and carry out an experiment on methods of producing salts applying what they learned from the poster they had produced earlier. They were able to work in pairs for this section if they wanted to. The last section – the A-layer was designed to allow for higher thinking skills and could be done at any stage of the unit. For example, in the acids and bases unit the student might have chosen to research about crystal formation based on acids and bases reactions. They needed to find some articles about crystals and then review the work that could then be presented in any format they chose. The purpose of this layer was to teach students to think critically.

Figure 2 shows the Layered Curriculum.

Figure 2 The Layered Curriculum



The first unit was done as a trial and based on the feedback given the subsequent units were altered accordingly. Rather than do any of these activities from any of the layers in every lesson, as was done with the first group, it was decided to produce the units as an assignment where the activities could be done at home for homework. The ICT room could be booked at various times to enable students to complete some of the work in class time and some activities could be completed as part of their normal class work. This allowed the researcher to teach using methods that are more traditional as well. It also meant that the researcher was able to spend more time being immersed with the students rather than only being able to mark each piece of work as it was handed in. A smaller number of activities were produced, which were all compulsory to do, but within each activity the students were provided with choices that they could complete that suited the various learning styles of the students. The lectures were taken out of the mix and the point value on some of the activities was altered to be more worth the time they took to complete. The activities were chosen based on aspects of the curriculum that the researcher deemed important to know. The researcher also found facilitating the activities to be rather time-consuming so adjusted the way in which the activities were collected and marked. This was done to make the gathering and marking of activities less of a burden. A table was produced to make the point collection and choices more easily administered.

Some students were still finding the workload difficult, so more class time was provided to work on the activities. The activities become more a part of the normal classroom work rather than homework. This suited the students better as a lot of them had numerous after school commitments plus a lot of homework from other subjects. The activities were used to assess what the students had learned as well as provide them with study notes in any format they chose.

3.4 Instruments used to collect data

This next section describes the instruments used in the data collection. Several different instruments were used to collect data. These were the achievement data (Section 3.4.1), which describes the grades of the students before and after the intervention. The instruments involved in the further collection of qualitative data are then described with the Ideas in Science Survey (Section 3.4.2), the Differentiated Unit

Survey (Section 3.4.3), classroom observations (Section 3.4.4), the case studies (Section 3.4.5) and the Open-ended Survey (based on the interview questions–Section 3.4.6).

3.4.1 Achievement Data

To determine whether the intervention was effective in terms of improving students' achievement (Research Question 2) school achievement data was collected from each of the 70 students before the study started and again at the end. To provide an indication of the level at which the 70 students were working, prior to the intervention, the previous years' examination results (or tests done at the beginning of the year if examination results were not available) were used. To examine whether students' achievement had improved, the examination results were collected at the completion of the 12-month period from either the external examination results or the school internal examinations. The Cambridge examination system is based on a set of nine grades. An A* grades is for students achieving over 90%, an A grade is set at 80-89%, a B grade is 70-79% with the grades going down in increments of 10% with a G grade being for students achieving 20-29% and a U grade being ungraded for those students below 20%.

3.4.2 Student Ideas on Science

The Student Ideas on Science survey was designed by the researcher to examine whether the intervention was effective in terms of improved views about science and can be viewed in Appendix D. All 70 students (including the 11 students who only participated in four of the five interventions) were administered the Students Ideas on Science Survey before the intervention commenced and again after it had ended to determine whether their views towards science had changed. The Students Ideas on Science Survey was made up of nine items that were grouped into four categories. The first question asked the students to indicate their gender and then to list which types of activities that the students liked or did not like doing. For example, if they preferred experiments or research work. In order to gauge the types of activities that students would be interested in they were asked to indicate from a list what their preferences were out of projects, research, experiments, computer based work and discussions. The aim being to help produce activities for the differentiated units.

Next, the survey asked students to identify which science subjects the students were enrolled in and why they had selected those subjects. The purpose of asking these types of questions was to gauge the reasons for students taking these subjects in the first place. The survey also looked at what science subjects the students were currently taking and why they were taking them.

The third component asked students about their views on careers in science. For example, whether they were considering a career in science and if they could name any careers involving science. The next part of the survey was used to determine the student attitudes to science as a career and the importance they placed on science in general. Students were asked to comment on whether they were thinking of taking science as a career before the course started. Finally, the survey asked students to identify what features of the lessons made science enjoyable for them. For example, the students were asked what would make science more interesting or enjoyable for them.

This survey provided data specific to Research question 1 and 4. The purpose of the survey was to seek information on the types of science activities that the students liked to partake in, the science subject(s) they were taking and whether they could name careers involving science. The survey also examined students' career interests and attitudes to science to determine whether these changed over the course of the intervention.

The survey was, therefore, made up of two parts. The first part was used to determine the types of activities that the students preferred as well as what would make science more interesting for them. This was done to see if the students would enjoy science more if they included those particular kinds of activities and could tailor the intervention so the researcher could produce a course of work that would contain elements of the student preferences within the program.

The second part of the survey was used to determine the student attitudes to science as a career and the importance they placed on science in general. This was done so that the researcher could have an idea of the attitudes of the students towards science before the intervention and then see how their ideas changed after the intervention. The main

purpose of doing that was to triangulate the results from the survey and interviews to enhance the accuracy of the study data and to ensure evidence was corroborated to enhance internal consistency and validity. A copy of the Ideas in Science Survey used in the present study can be found in Appendix D.

3.4.3 Differentiated Unit Survey

The purpose of the Differentiated Unit Survey was to collect data on the program to determine if differentiated units would encourage students to take science further and possibly as a career. The data was collected after the conclusion of each of the five differentiated units. Information gathered from students included the: choices of activities, preferred learning style, the A-layer section on higher level thinking and what they liked and disliked about the unit. The survey can be found in Appendix B. This survey was used to provide information for four of the research questions— Research question 1, 5, 6 and 7 as shown in Table 3.1.

The survey asked students to recall what was their preferred learning style and later the types of activities they chose to do. The students were then asked why they chose those activities and whether there were enough activities to suit their learning style (Research question 5). Students were asked: What types of presentations have you chosen in the C-section? What made you decide to choose those particular ones to do? Was there enough to choose from to cater for your learning style(s)? Give further detail. What else would you like to see included?

Students were required to write a goal for each differentiated unit and then comment on how well they meet their goals (Research question 7). Typical questions were what was your goal for this unit? Did you meet your goal? Why or why not?

The students were then asked to make various comments on the research component of the differentiated unit and whether a higher level of thinking was required to complete the work (Research question 6). What made you decide to choose that/those particular one(s) to do? Did you complete every task for the area you choose to do in the A-layer section? Give further detail. What did you complete?

What didn't you complete? Why not? Did writing your opinion make you think about the topic? Comment on this.

Students were also asked to comment on what they liked or disliked about the unit and why which contributed to Research question 5. The comments made by the students in this survey also contributed to Research question 3, which covered self-regulation, personal agency and self-efficacy. The questions were all open-ended and allowed the students to contribute further to their questions.

These units of study covered a range of topics: acids and bases, cells and organisms, organic chemistry, electricity, earth science and astronomy and reaction rates to name a few. All students who covered five of these units were included in the Differentiated Unit Survey used at the completion of each of the five units. A copy of the Differentiated Unit Survey used in the present study can be found in Appendix B.

3.4.4 Classroom Observations

Throughout the course of the study, the 70 students were observed on a regular basis to provide insights into including such things as whether the students had chosen activities that catered to their learning styles or whether students showed personal agency, resilience and self-efficacy and commitment to work. The observations provided data for three of the research questions-Research question 1, 3 and 5

The researcher as a participant observer took part in continual observations of the students. As the students involved in the intervention were students in the researcher's class, she was an accepted part of the group and observations could be made without disrupting the ongoing flow of the class. The researcher was immersed in the research by spending a lot of time with the participants (Humphrey, 2011). This allowed the researcher "to see experiences from the views of participants" (Creswell, 2012, p.214) and enabled the researcher to record information while engaging in the activities.

The students were observed every period during the course of the lesson over the 12-month period. Field notes were recorded whilst the students were involved with activities or directly after classes were completed. The notes covered discussions by

the students, attitudes by the students, problems experienced by the students and interactions between the students and the researcher.

3.4.5 Case studies

The purpose of case studies is to show transferrable data to other settings that may be similar (Blose, 2003). Case studies involve a small number of cases that are studied in more detail in a natural setting (Punch, & Oancea, 2014). According to their research, this aids in organising the data so the case study can be understood in as full a detail as possible. The case study can be an individual, a small group, even a decision, or an event.

Eleven students of the 59 students who participated in the intervention were part of the case studies. The sample is described in Section 3.4.2. These students were extensively surveyed and observed throughout the five differentiated units. They were also questioned on the observations made by the researcher as well as the surveys to clarify the responses. These students also took part in extensive interviews at the end of the study on their views about choosing science in higher levels of education and perhaps even going on to choose science as a career. The interview questions can be found in Appendix F. The interviews were done to triangulate the views of the students from the responses received from the other instruments.

This section has described the various instruments used in this study including surveys, achievement data, case studies and classroom observations. The next section will describe the participants used in each of the instruments.

3.5 Data analysis

This section describes the analysis of the data to answer the various research questions and has been analysed in accordance with the various instruments used in the study. Section 3.5.1 describes the analysis for the interview data; Section 3.5.2 describes the analysis for the surveys; Section 3.5.3 describes the analysis for the achievement data; and Section 3.5.4 describes the internal validity of the data.

3.5.1 Interview data analysis

Sixty-one students were involved in the collection of data for the interviews. Fifty students participated in the Open-ended Survey (based on the interview questions), which was completed on-line and 11 students were involved in the case study and participated in extensive interviewing. The on-line data was collected in an excel spreadsheet using headings that related to the interview questions. The interviews from the case studies were transcribed within 24 hours of being conducted and typed into a word document. The data was interpreted to generate a general explanation of how the views of the participants changed over time. The interviews were recorded by audio and stored as MP3 files that were transcribed verbatim for analysis at the end of the intervention. During the interview process data was reiterated to the participants to confirm or alter to ensure accuracy of data.

For both sets of interview data, the researcher read the data to “develop a general sense of the data” (Creswell, 2012, p.237). The data from case studies was then incorporated into the excel spreadsheet containing the data from the Open-ended Survey (based on the interview questions). The data was continually read and reread to generate themes for each question in conjunction with observation notes made during the study. Thematic analysis involves pattern recognition where “emerging themes become the categories for analysis” (Fereday, & Muir-Cochrane, 2006) By encoding information data can be organised and themes developed thus reducing the number of codes into categories (Unkart, 2014). By rereading the data, the themes were broken down and coded into categories and then colour coded in the excel spreadsheet by adding colour to each of the cells containing similar ideas. For example, the question relating to whether a choice of activities meant they were more interested in science showed the emergence of seven themes for those students indicating that yes this was the case. These seven themes were coloured using seven different colours, which made the tallying of each theme easy to do, and comparisons could be made. Results were interpreted based on the researchers own ideas and how she made sense of the data.

3.5.2 Survey Data analysis

The Students Ideas on Science Survey data was collected as pre- and post-data, while the Differentiated Unit Survey data was collected after each unit for five units as a time series method. The data was placed into an excel spreadsheet set up as a data grid. Representing qualitative data can be difficult when researchers want to ensure the data is reported correctly without misinterpreting the findings (Wise, Plowfield, Kahn, & Steeves, 1992). In processing the survey data, the raw data was originally coded and then grouped according to the themes that formed the major ideas produced by the students. This was done with both the surveys. Producing themes is a way of making sense of the data that is used in qualitative analysis to make the analysis more manageable (Bryman, 2012; Creswell, 2012). Themes can be used to recognise patterns in the data and these themes become the categories that get analysed (Fereday, & Muir-Cochrane, 2006).

Each data set was coded so data could be organised in a logical manner in relation to the research questions. Themes were developed based on the data collected. For example, students could choose the activities they wanted to do which helped them understand the work better. Themes included, they learned the work better, related to learning styles, work was reinforced in the activities they did and the work was easier to understand.

Each theme was colour coded a different colour for ease of organising the material. The analysis provided data for the following research questions: Research question 1: Does the use of a Layered Curriculum approach to differentiated learning lead to improvements in student enjoyment of science lessons allowing students to become more interested, more engaged and more motivated to take science? If so, why? Research question 4: Is there a relationship between differentiated programs of work and subject selection in subsequent years leading to a career in science, and to what extent do students know about science related careers? Research question 5: Do students perceive the choices prescribed for differentiated programs of work sufficient to match their learning styles, and do these choices reflect the types of activities the students then choose to do and what changes would they make to the activities?

Research question 6: Do various forms of differentiation allow for higher level thinking for all students, as well as engagement and motivation, and what do students perceive to be improvements to the A-layer section of the differentiated program?

Research question 7: Is there a relationship between differentiated programs of work and student aspirations for their assessment level?

3.5.3 The achievement Data Analysis

This data was collected both pre- and post-intervention. The data were grouped into grades based on the Cambridge system as described in Section 3.5.2. The change in numbers achieving particular grades was noted, as well as individual changes in results over time. The data was placed into an excel spreadsheet and coded according to the grades. The analysis was used to determine whether the intervention was effective in terms of improving students' achievement (Research Question 2).

3.5.4 Internal Validity

Triangulation allows a researcher to verify findings by using independent means that agree with the findings (Meijer, 2002). Triangulation by method combines the data collected with different instruments to produce a comprehensive view of the participants to corroborate evidence so in order for the data to be credible information is drawn on multiple sources (Creswell, 2012). In this study, several different instruments were used to triangulate the data – surveys, interviews and observations. To ensure internal validity a number of areas were included: the participant observer conducted in the school setting, the observer as an accepted member of the group, continual contact with the participants over the 12-month period and member checks. This next section describes these areas in more detail.

3.5.4.1 Participant observations

The researcher was immersed in the study as a participant observer. This allowed the researcher to study the students in their natural setting without disruption to the natural flow of the class. This is an important component of ethnography (Symons, 2012). Participant observation allows the researcher to get close to the participants and

observe what they do (Gans, 1999). The researcher was an accepted member of the group, as the students knew the researcher being members of her classes. This meant a good rapport with the students was established and the relationship was built on trust. At all times the students were aware of what the study entailed and gave their consent freely. Every effort was made to ensure the responses from the students were honest and genuine. The researcher had continual contact with the students over the 12-month period and the study became part of the normal activities done in the classroom.

3.5.4.2 Member checks

Data can be validated by doing member checks. This involves the researcher “checking the findings with participants in the study to determine if their findings are accurate” (Creswell, 2012). Participants check on how accurate the account is by the researcher asking during the interview process or in some written format. In this study, the researcher used member checking to help validate the data. This was done during the interview process when the researcher was questioning the participants and getting them to verify what they were saying was correctly interpreted and during the five units with the Differentiated Unit Surveys.

3.6 Ethical considerations

Ethical issues need to be considered by the researcher throughout the research process to avoid “inhumane treatment of participants” (Creswell, 2012, p.27). Ethical approval was obtained from Curtin University. Other ethical considerations involving confidentiality and maintaining anonymity (Section 3.7.1), addressing power relationships (Section 3.7.2), participation and consent (Section 3.7.3) and impact on participants (Section 3.7.4) are discussed in the following section.

3.6.1 Confidentiality and maintaining anonymity

Throughout the research process, the participants were considered to ensure they were not impacted in any way by the being involved with the study. Students remained anonymous by having any responses numerically coded or by using pseudonyms for each student, so students could not be identified at any time throughout the course of

the research or after when the findings are reported. The researcher and the supervisor only viewed the data collected.

3.6.2 Addressing power relationships

The researcher was immersed in the study and was familiar with the students in the study. To address the issue of power relationships the students were fully informed about the purpose of the study and able to remove themselves from the study without prejudice. Students were considered at all times and shown respect.

3.6.3 Participation and consent

Students were invited into the study from a lower secondary school. Potentially sensitive data was collected. Consent was sought directly from parents/guardians to conduct the research using consent forms that included a letter explaining the nature of the study and details of what the students would be doing. Students also signed the consent form. A copy of the consent form has been included (see Appendix G).

Students at all stages were respected both in terms of privacy and in terms of their emotional wellbeing. Students were able to ask questions and clarify any information regarding the study prior to data being collected. Permission was also sought from the school in question and from the Principal of the school to conduct the research.

3.6.4 Impact on participants

All the activities involved in collecting data were normal activities for students in school. Teaching and learning continued in this study so as not to impact on the students. Interviews were scheduled during normal class lessons to avoid inconvenience for the students. Participants were able to withdraw at any time without prejudice.

3.7 Chapter Summary

The overarching aim of this study was to examine whether a differentiated approach in teaching science was effective in terms of motivating students to choose science as they progress to higher levels of education and their future career aspirations. Further, this study investigated whether teaching students in a differentiated science course would improve their attitude to science and level of thinking.

The research design was based on ethnography with the researcher immersed in the learning environment with the participants as a time series design. Students were involved in five differentiated units in a post-test survey. Multiple forms of qualitative data were collected including achievement data, surveys, interviews and case studies.

Participants responded to the TOSRA, which was used to purposely select students suitable for the case studies. Achievement data was also collected. Seventy students from five intact classes were involved in the qualitative data collection to varying degrees.

Data was analysed according to the interviews and surveys. How this was done was described in terms of coding and themes. The achievement data and how this was analysed was described next followed by the internal validity of the data.

The last section reviews the ethical considerations of the research including confidentiality and maintaining anonymity, as well as addressing power relationships. Consent was sought from the participants and students were invited into the study. Activities involving the collection of data were normal school activities so not to impact on the students in any way.

This section has described the research design in terms of the participants, the instruments and the data analysis. Ethical issues have also been taken into consideration. The next section describes the results of the data collected from all the instruments.

Chapter 4

Results

4.1 Introduction

The previous chapter described the methods that were used to conduct this study. Based on the analysis of information gathered using classroom observations, pre- and post-test surveys and interviews (see Chapter 3 for more information). This chapter focuses on the evaluation of the five differentiated units and how the student's ideas changed over time. This chapter presents the results of the analysis of the data used to determine the effectiveness of differentiated programs from the different instruments.

The findings are presented in seven different sections. The sections are in terms of differences in: students' enjoyment (Section 4.2); achievement (Section 4.3); self-regulation, personal agency and self-efficacy (Section 4.4); subject selection and careers choice (Section 4.5); choices and learning styles (Section 4.6); higher level thinking (Section 4.7); and student aspirations (Section 4.8).

Seventy students participated in the differentiated program of work over a 12-month period with 59 students completing all five units and a further 11 students who completed four out of the five units. Of the 70 students who were involved in the differentiated program, 50 agreed to respond to the Open-ended Surveys (based on the interview questions) at the end of the intervention with a further 11 of these 70 students involved as case studies. This section describes the results of the analysis of data gathered from 50 students as well as the 11 case studies to determine whether the intervention was effective in terms of improved students' enjoyment of science lessons.

The researcher first became interested in studying this topic when she was presented with a particularly difficult group of students who showed very little interest in science (or work in general). The group consisted mainly of Year 10 boys who were of mixed ability. The higher ability male students did not have a good work ethos and showed a tendency to be lazy (as they had not had to work hard in the past). The low ability students also did not apply themselves, as they found the work to be too difficult. Most

of the girls had been assessed by the school as low to mid ability (based on school assessment results in science). Although they generally tried, they struggled with the work. The boys were generally disruptive, and much of the teacher time was spent disciplining these students and providing classroom management activities, rather than a focus on learning science content or activities. Homework was generally poorly done, if at all.

4.2 Student enjoyment of the units

This section reports the analysis of the data used to answer Research question 1, which asked:

Does the use of a Layered Curriculum approach to differentiated learning lead to improvements in student enjoyment of science lessons allowing students to become more interested, more engaged and more motivated to take science? If so, why?

Engaged students are students that put in a lot of effort, are persistent, use goal setting techniques and enjoy the challenge of the work involved (Christenson, Reschly, & Wylie, 2012). Motivation, in the present study, was considered to be “the internal drive directing behaviour towards a goal, has a timely, complex and intense influence on students’ ability to complete and master their school work” (Sanchez Rivera, 2010, p. 8).

In this section students’ attitudes towards the differentiated unit was determined in terms of their enjoyment of the work to show motivation and engagement. This section describes the overall findings for student enjoyment of the units (Section 4.2.1); and goes on to describe the reasons why students enjoyed the differentiated units (Section 4.2.2).

4.2.1 Overall Results for Enjoyment

Data was collected using a number of different instruments. These were the Differentiated Unit Survey, Open-ended Survey (based on the interview questions),

in-depth interviews with the 11 case study students and classroom observations and were used to answer this research question.

The results of the Differentiated Unit Survey, suggest that, across the five differentiated units, an average of 98% (58 out of 59 students) of the students reported that they enjoyed all five units. For example, one of the students said, “I really liked everything about it” [Student 36]. Another student said, “I enjoyed everything. It was fun to find out information on the topics. They were interesting and there were many choices. Everything was fun” [Student 49].

Students’ responses to the enjoyment scales of the TOSRA (administered prior to the commencement of the intervention), suggested that only 23 of the 59 students (39%) enjoyed science lessons often or very often. This score was in contrast to the results of the differentiation survey, which indicated that, for each of the five units, more than 95 percent of the students expressed enjoyment of their science lessons. This lack of enjoyment, prior to the intervention, was also reflected in the classroom observations, in which students generally indicated a lack of interest in science lessons. It was this lack of interest, which provided the impetus for the study.

Analysis of the data collected from the 11 case study students also reflected this improved enjoyment of the science lessons during the intervention lessons. These students indicated they enjoyed the differentiated units more than before the intervention (based on the TOSRA results).

For example, one of the students, Case study 5, indicated that he did not enjoy science lessons before the start of the intervention, recording a score below the mean for the total sample on the TOSRA. During the intervention; however, observations showed Case study 5 being involved during the intervention. For example, he spent over 30 hours creating a board game with the dice he produced along with the questions he had made up. He stated, “The board game took a long time to do, but was fun to make. I enjoyed making the board game and the crosswords as they turned out well.” With respect to the board game, one student commented, “he should market it” [Student 16]. Case study 5 also spent over 20 hours making the animated video on drug testing. “I knew nothing of the topic beforehand and thought that not many people would pick it.

I liked creating the animations and presentations. During an interview about one of the units, Case study 5 stated, “I enjoyed the super hero research as I was interested in it.” This student spent a lot of time researching whether the science behind the super hero’s powers was sound. He had a great fascination for this research and was eager to discuss his findings with the researcher.

In another unit, the same student produced an animated PowerPoint but before he could produce one he had to teach himself how to go about making it, and consequently spent over 20 hours producing the work. It was interesting to note that the PowerPoint this student produced was an amazing animation depicting rates of reactions involving cars racing around the track under various conditions. He spent a lot of time discussing what he was doing with the researcher, stating:

I liked making the animations in the PowerPoint. There was enough to cater for my learning style as I was given freedom with the PowerPoint. I often spent a lot of time on the activities more than was required for the number of points allocated [Case study 5].

According to the Open-ended Survey (based on the interview questions) Twenty-one students out of the 50 (42%) enjoyed every aspect of the differentiated units. One student stated, “Everything was fun” [Student 49].

4.2.2 Reasons for enjoying the units

Analysis of the data indicated that there were a number of reasons why students enjoyed the units. The results indicated that the students’ enjoyment of the activities centred around five broad themes, these being that the activities: were fun to do; were interesting to do; helped with their learning; were easy to do; and were visual.

The results for the Differentiated Unit Survey was used to provide a percentage of the students who indicated that these as reasons for enjoying the lessons. The breakdown for each unit is shown in Table 4.1 and the results for each are discussed below.

Table 4.1 *Reasons that number of students enjoyed the units due to choice*

Unit	Numbers who enjoyed the units due to choice as activities				
	Were fun	Were interesting	Helped with learning	Were easy to do	Were visual
1	18 (31%)	07 (12%)	12 (20%)	02 (03%)	10 (17%)
2	25 (42%)	03 (05%)	09 (15%)	07 (12%)	09 (15%)
3	21 (36%)	09 (15%)	07 (12%)	09 (15%)	07 (12%)
4	18 (31%)	10 (17%)	16 (27%)	06 (10%)	12 (07%)
5	20 (34%)	06 (10%)	07 (12%)	07 (12%)	09 (15%)
average	20.4 (36%)	07 (12%)	10.2 (17%)	6.2 (11%)	9.4 (16%)

n=59

4.2.2.1 *Choice of Activities*

Based on the interview data, it would appear the students' enjoyed the activities largely because they were able to select the activities that they wanted to carry out. When asked why they enjoyed the differentiated units, one student said, "I could do what I wanted" [Student 45] and another stated "I liked the freedom of choice" [Student 16]. Still another stated that the units were enjoyable because she "Could choose the fun things to do" [Student 57]. Finally, another student stated, "Definitely the choice of doing different tasks and not being stuck on one track was enjoyable. It gave you more freedom" [Student 3].

The students liked that it was not restricting and for some was something, they had not done before. The freedom of choice made the topic easier to understand and was productive for them. One student commented, "Other classes are limited in the range of choices" [Student 73] so those classes were not as fun.

According to the Open-ended Survey (based on the interview questions) the students were asked whether having a choice of activities made them enjoy science more so they were more interested in studying science and to explain their answers. Forty-two students out of the 50 (84%) indicated that yes having a choice made them more interested in studying science. Students that responded yes to the question gave the following types of reasons. Five out of the 42 (12%) said it gave them more control. Twelve out of the 42 (29%) found it more enjoyable. Twelve out of the 42 (29%) liked the idea of choosing. Five of the 42 students (12 %) felt that being able to select the

activity that they liked meant that it was more likely to suit their learning styles. Of these five students, four felt that by having an activity that better suited their learning style meant that they learned more from the work. Two of the five students felt that having a choice made the work more interesting and two stated it was easy to pick the activities. One student who felt they were given more control stated, “I get to choose what I want to do which makes it more flexible for me” [Student 58]. For those finding it more enjoyable comments included “I found that it made it science more enjoyable as we had choices we could make rather than sticking to one method” [Student 36] and “I could choose what I enjoy and like to do so I was a bit more enthusiastic about doing the homework tasks” [Student 59]. The students liking the idea of the choice of subjects included statements such as, “It does because you’re not limited to a small range of choices like other classes usually would” [Student 28] and “It gives more choice. So, if there is something you are not really motivated to do there might be something else that you are” [Student 3].

Concerning being able to choose one student stated, “Being able to do experiments and project work definitely makes me interested in science because we have choices to choose from to cater for our learning styles” [Student 43]. One student who learned more from the work said, “Because I was able to learn more about each subject than I usually would in a normal science class” [Student 48]. One student said, “I believe it does. It is more interesting than just looking at a blank piece of paper. It is more interactive” [Student 11]. Another student in relation to picking the activities said, “Over a wide range of activities, it's quite easy for me to pick what activity to do” [Student 20].

Having a choice of activity meant that, for many students, they were fun to do. As reported in Table 4.1, an average of 36% of the students stated that they enjoyed the differentiated units because they were fun. Students often provided more than one reason why they were fun. For example, Case study 7 stated, “I thought there were a good variety of posters, PowerPoints, experiments and worksheets. I chose these activities because they were easy and fun to do. It was easy to learn at the same time as doing the activity.” Another student, Case study 9, said, “It was a chance to be creative and I could do it in my own time. It looked like fun. I enjoyed making PowerPoints and web pages. It was easy to do on the computer and was fun.”

As reported in Table 4.1, on average 12% of the students described the activities as being enjoyable because the choices they made were interesting. For example, on students said, “The experiments and the chemistry of it interested me” [Student 59]. Another, Case study 6 said, “In the A-layer I chose to do PET scans as I thought it would be interesting, so I would enjoy it more.” Case study 3 responded, “I like doing PowerPoints and arty type things as they are more interesting.” Case study 1 stated, “I liked doing the activities that interested me.” Case study 11 said, “It was a choice and that you didn’t have to do everything. It was an interesting way of doing it.”

On average 17% of students as shown in Table 4.1 described the activities as enjoyable because by being able to choose the activities meant they helped them with their learning. One student summed this up when she said:

I chose the ones that I thought looked the best and there were lots to choose from in the unit. They were fun and the most valuable to my learning. I like making websites. It helps me to learn because I write down things and it helps me to memorise. I enjoyed doing the website, research, database activity and the PowerPoints. I like these ones because they are enjoyable, and I learn lots from them [Case study 7].

Many similar statements reflected that the students often enjoyed the activities because it was helpful, for example, “I chose to do study notes as I found it helped me learn and remember organics as well as get homework completed” [Case study 2]. Or it made the work easier to remember, “I chose the activities because they were colourful, visual and they were easy and fun. This made the work easier to see and remember” [Case study 9]. Or taught them something new, “It made me realise how bad smoking was” [Student 43]. For other students, enjoyment of the units stemmed from their usefulness in terms of study. “It was a good resource to study” [Student 15]. “It helped with learning” [Case study 6] and that it helped them to learn. “It was fun and I could learn at the same time” [Student 30], and “It helped me with my learning as well as being interesting” [Student 14]. Finally, of the units, Case study 1 said, “You really find out more about the research. You really find out new things that you do not know about. So, it’s a motivator to learn about new things so I enjoy it.”

On average 11% of students, as shown in Table 4.1, enjoyed the activities because they were easy to do. Case study 3 said, “I chose the activities I did as I like the design side and they are easy ways to display information.” Case study 10 responded, “I liked doing the PowerPoints as they were easy to do in a quick amount of time. I liked making the model for this reason. I found the work on spider silk to be interesting and easy to do.” Case study 11 stated, “I liked the ones to do with the computer as it was easier for me.” While another one said, “It made the topic easier to understand” [Student 14].

While 16% of students, as reported in Table 4.1, choose the activities they did, as they liked visual activities. Students made comments such as, “I like to see and observe real science” [Student 43], “I like to visually see things” [Student 14] and “I understand better when I try things in person” [Student 9].

Often there was more than one reason given. Students often liked more than one aspect of the activities. For example, Case study 6 said, “I like the group work and the computer work because it was easier and more fun.” Another student stated:

I liked creating PowerPoints. I liked doing that for some of my C-layers even though the time was quite disproportionate to the mark. I liked creating the animations and presentations. I enjoyed some of the A-layer topics but not all of them. With the research I did, I liked the ones that related to my interests such as the one about spider silk. I could relate it back to my interest in Spiderman and the possibilities of that and I enjoyed the versatility of the superhero one [Case study 5].

Ten out of the 11 case studies indicated that choosing activities made science more enjoyable for them. One student stated, “You can choose activities that suit your interest and what you enjoy creating makes a difference” [Case study 1]. Another stated, “I liked the choices. To be able to choose what we could do made it more interesting and enjoyable” [Case study 3].

Over the five units, Case study 1 demonstrated that a layered approach to differentiated learning lead to improvements in student enjoyment of science lessons allowing students to become more interested and more engaged. From what the researcher

observed of Case study 1 she felt that having choices made the work more interesting to do and motivated her to do the work. She stated, “I enjoyed researching up and learning about new areas that I hadn’t yet before known much about. I like being able to expand my knowledge and I was able to do that through this” [Case study 1]. She described the work as being fun and interactive. It also allowed her to be creative at times. Students were able to see success with this program, which further motivated them to do the work.

Case study 10 was the sort of student who found everything boring, usually because he found the work difficult. He became very excited with the activities when he discovered he could actually do the work and achieve. He became very motivated to send his work to the researcher electronically at different times throughout the weekend and school holidays. This was from a student who was not good at handing in work on time. Case study 10 also felt able to try out new activities. By being able to choose the activities, he was more interested in studying science. He liked that he could choose which ones he did. “There were different topics of activities to do. I liked having the different choices” [Case study 10]. He described many activities as being fun and easy to do and he could use the computer. “I did not know what tasks to choose from so I can choose the tasks that I enjoyed like the PowerPoints, creating word finds, research and textbook work” [Case study 10]. With some activities, he chose them because it motivated him to find out about the work, as he did not know anything about the topic. “I did not know what nuclear fission was so I chose this activity” [Case study 10]. He described this as something he enjoyed doing.

Over the five units, Case study 11 also demonstrated that a layered approach to differentiated learning lead to improvements in student enjoyment of science lessons allowing students to become more interested and more engaged. By being able to choose the activities, he was more interested in studying science. He liked that he could choose which ones that interested him or that he would prefer to do. Case study 11 choose the activities he did, because they were easier, and they involved computer work. It enabled him to complete his goals. He really liked the simulation program another student found called “Powdertoy”. He described the program as being fun as there were many pretty explosions. Therefore, even though he found it hard to get

started at the beginning of the course he found this improved as he went along. “Then we eventually got into it and then finished it” [Student 11].

Analysis of the data gathered from the Open-ended Surveys, the differentiated units and the in-depth interviews with the case study students indicated that there were a number of reasons for their enjoyment of the units. The reasons included the hands-on nature of the activities; being involved in researching; the use of the computer, and the choice for students to opt to work with others if they wanted to. Each of the reasons are described in Section 4.2.2 to 4.2.5.

4.2.2.2 Hands-on aspect

Analysis of the data indicated that one of the things that the students enjoyed about differentiated units was the hands-on aspect of some of the choices. Creative activities (which included making models, producing games or videos, making up crosswords or activities involving posters and brochures) were very popular with an average of 39% of students opting for these types of activities over the five units. See Table 4.2.

Table 4.2 *Number of students who enjoyed various aspects of the units*

Unit number	Numbers of students over the five units who enjoyed:			
	Hands-on activities	Research activities	Computer activities	Working in groups
1	30 (51%)	06 (10%)	05 (08%)	07 (12%)
2	35 (59%)	08 (14%)	06 (10%)	06 (10%)
3	16 (27%)	18 (31%)	10 (17%)	06 (10%)
4	17 (29%)	15 (25%)	13 (22%)	04 (07%)
5	16 (27%)	17 (29%)	17 (29%)	04 (07%)
Average	23(39%)	13 (22%)	10(17%)	05 (09%)

n=59 students

The findings suggested that the students enjoyed doing hands on activities, such as experimental work or creating activities. Although the number of students who enjoyed these activities decreased with the later units from 51% down to 27% as shown in Table 4.2, it would appear that this was because the students started to enjoy other types of activities. Of the hands-on activities, one of the students explained that she

enjoyed them because, “I could put art on it and decorate it so I enjoyed it more” [Student 39].

Classroom observations also indicated that, as the units progressed, the students were opting to do additional types of hands-on creative activities, such as song writing and producing children’s books. For example, Student 55 expressed an interest in music. This student was in the orchestra and the school choir and showed musical intelligence as very high on her learning styles profile. This student started to produce songs for her preferred activities, which she videoed, and was keen to show them to the class. She stated, “I liked making songs as I really like singing. I can understand it in the way I enjoy.” Another student said:

I decided to go for trying something completely different, so I did a song/poem. Still not sure about it, but oh well. I hope that it will make me remember it better, which was another reason why I tried something different [Case study 1].

Student 48 decided to produce a children’s colouring book on the planets as she enjoyed hands-on activities. In one of her responses to the Ideas in Science Survey, administered before the intervention, she indicated that she enjoyed creative hands-on activities, as it made her “more interested in learning about science”. This enjoyment was reflected in the units, which provided more scope for this type of activities. To this end the student said, “I enjoyed making the PowerPoint, the model was fun and the brochure was cool to do.” When, in a later unit, she opted to do the colouring book she said, “It was something unique that I haven’t done before. It was something different than I usually do.” She stated, “I could understand more by putting the information into a presentation form that suits my style of learning.”

On the same note, another student commented, “I have never done a cartoon before” [Student 12] whilst Case study 7 said, “I never made one before and so it was enjoyable and it helped me to remember key points.” This was in reference to creating web pages. She went on to say, “I think I saw someone doing them and I wanted to try it.”

4.2.2.3 Research Activities

Analysis of the data indicated that another reason that students enjoyed the units as they involved research activities. As reported in Table 4.2, the research activities became a popular option as the units progressed, with 22% of students enjoying the research activities over the five units. According to the Differentiated Unit Survey, students enjoyed the researching activities for a number of reasons: students could learn new things and the research related to the environment. These same reasons were also given by the 50 students involved in the Open-ended Surveys (based on the interview questions), and the 11 students involved in the case studies. As one of the case study students, when referring to the A-layer said:

I enjoyed researching up and learning about new areas that I had not yet before known much about. I like being able to expand my knowledge and I was able to do that through this. I chose to research medical uses of Nuclear Radiation in the A-layer because I enjoy researching and expanding my knowledge so this activity interested me [Case study 1].

Another student said, “In the A-layer I was interested in chemical testing so decided to do that activity. I wrote the script for the video and researched the topic. I enjoyed researching the information and learning new things” [Case study 6]. One student stated, “I liked researching topics that are relating to environment and us” [Case study 4]. Further findings will be presented in Section 4.7 on the research activities, and how the use of these research activities related to higher level thinking.

4.2.2.4 Computer based activities

Another aspect the students enjoyed about the differentiated units was being able to use the computers. At the start of the intervention, only a minority of students (five of the 59) chose to do computer-based activities. According to the Ideas in Science Survey only 3 out of the 59 students indicated that science would be more enjoyable if lessons included computer-based activities before the intervention started. Students generally stated in this survey they preferred experimental work rather than computer based work with one student commenting, “Science is more interesting when you get

to do more experiments or go on science trips and not using computers as much” [Case study 7].

Over the course of the intervention; however, these types of activities became more popular. The students enjoyed producing webpages or enjoying researching on the internet. See Table 4.2. Case study 7 stated that by the end of the intervention she was enjoying computer-based activities more than she did at the beginning. She commented, “By the fifth unit I really enjoyed the computer activities such as making the webpages, researching on the internet, using the database Bestchoice to help with our knowledge and producing PowerPoints.” On average 17 per cent of the students chose computer-based activities over the five units. Analysis of the data indicated that students liked to do computer-based activities such as: PowerPoints, or database activities and webpages, as they found them to be more enjoyable than writing, which was often described as tedious. One student said, “I don’t like activities that require a lot of writing as they are not enjoyable” [Student 24]. When talking about why he enjoyed the intervention lessons, one student wrote, “They were fun as I could use the computer” [Case study 10]. Another stated, “It was interesting due to the computer options” [Student 6]. One student said:

I could create items how I wanted them such as PowerPoints, posters and the webpage. I chose them because they were visual and easier to study from. I chose to do the webpage as I could keep adding to it. I liked creating the website, as I like to do things on the computer [Case study 9].

Still another student explained why he chose to use the computers: “I liked making the animations in the PowerPoint” [Case study 5].

Although, during the first unit, the researcher observed that only one student produced a webpage, as the units progressed more students were choosing to make webpages. One student explained that the webpages were, “Easy to do on the computer and fun” [Case study 7]. One of the case study students reported:

I could make them [webpages] on my computer and upload them to my website. I chose to make a webpage, as it was fun and educational. I also chose to do a PowerPoint and video on spider silk, as it was interesting [Case study 8].

Another stated:

I did a web page, which I had never done before, and I wanted to try it. It was fun. I like making websites. It helps me to learn because I write down things and it helps me to memorise things. I enjoyed doing the website, research, database activity and the PowerPoints. I like these ones because they are enjoyable, and I learn lots from them [Case study 7].

4.2.2.5 Working in with other students

A small number of students stated, that they enjoyed the Layered Curriculum approach because it allowed them to work with other students. Table 4.2 reports these numbers, indicating that nine percent of the students reported that they enjoyed the different units more because of this opportunity. For example, one student said, “I like working in a group. It’s fun to work together and share the load” [Case study 3], and another liked that it could, “Enable interactions with others” [Case study 2]. One student stated, “Working with others helped me understand the assignment from a different perspective” [Student 58]. Another said, “I could do more projects than written things and we could do the A-layer as a group. I like the projects and being able to work as a group. Our group chose the activity together. I didn’t do anything I would not enjoy” [Case study 3]. Another stated, “Because I did it with my friend, I feel that we were more motivated now than doing it by ourselves. We are probably aiming higher” [Student 23].

This section has presented the data for the findings on enjoyment associated with differentiated learning and will be further discussed in Chapter 5. The next section presents the findings for student achievement.

4.2.3 Aspects of the unit students did not enjoy

According to the differentiated unit findings, the students did not enjoy all of the activities over the five units. An average of 1.2% over the five units did not enjoy any of the activities in the unit. For these students, the dislikes were related to the nature of some of the activities. There were activities that on average 2.7% of the students

did not enjoy any aspect of the whole unit, and mostly, these involved the writing activities, which they found were, “Boring and involved repetitive copying” [Student 26]. Time constraints was another reason why 0.3% of the students did not like any of the activities in a unit finding them to be time consuming. They made comments such as, “Too much to do and took a long time” [Student 9]. For 0.68% of others, they did not like the topic or they had done that aspect of the topic before. They voiced their suggestions with comments such as, “I don’t like biology” [Student 53]; “I already knew it” [Student 59]. In every unit, if there was one thing that students did not like about the units they were based around five broad themes: too much writing; the research; specific topics; hands-on activities, and time constraints.

Table 4.3 *Number of students that did not enjoy one aspect of the units*

Unit	Numbers of students over the five units who did not enjoy:				
	Writing	Research	Specific topics	Hands-on	Time factors
1	14 (24%)	06 (10%)	10 (17%)	05 (08%)	0 (00%)
2	11 (17%)	02 (03%)	05 (08%)	02 (03%)	04 (07%)
3	05 (08%)	13 (22%)	08 (14%)	02 (03%)	04 (07%)
4	09 (15%)	12 (20%)	03 (05%)	02 (03%)	05 (08%)
5	10 (17%)	06 (10%)	06 (10%)	02 (03%)	02 (03%)
average	10 (17%)	08 (13%)	6.4 (11%)	2.6 (04%)	03 (05%)

n=59 students

On average 16% of the students, stated writing was the one aspect they did not like about the units. One student commented, “I don’t like activities that require a lot of writing as writing activities are not enjoyable” [Student 24]. Researching was not enjoyable to 13% of the students on average. One student responded, “I like the fun ones; like making a book, but not really the research ones” [Student 55]. For 10.8% of the students on average, specific topics were an aspect they did not enjoy. One student stated, “I did not like learning about photosynthesis as I already knew about it” [Student 59]. Four percent of the students did not enjoy hands-on activities stating, “I did not like the creative and arty type of activities as I don’t find them helpful” [Student 17]. Whilst 5% of the students stated that time was the reason, they did not enjoy some activities. One student stated, “I did not like the length of time it took to design the test. It took too long to do even though it was fun” [Case study 9].

These results were further corroborated by the Open-ended Survey (based on the interview questions) results collected at the end of the intervention indicated there were some aspects of the activities that students generally did not like, including: the amount of choices involved with the activities: the work load; the research; writing; or they found the work boring, or time constraints. When asked what they did not like 10 students out of the 50 (20%) indicated there was nothing they did not like doing, as they liked everything about the units. One student stated, “I was happy enough with what was there” [Student 59]. Nine out of the 50 (18%) found they did not have enough choices with one stating, “When I didn't get much choice and had to complete something I didn't enjoy so I didn't put much effort into it” [Student 30]. Five of the 50 students (10%) found the workload to be high and one said, “I didn't like the multitude of activities” [Student 14]. Four students out of the 50 (8%) did not like the research with one student saying, “I didn't like the A layer as it took a bit of time” [Student 8]. Another four out of 50 (8%) did not like the writing with one student stating, “The way that there was more book work than experiments” [Student 43]. Three of the 50 (6%) students more found the work boring with one student commenting, “Sometimes the activities are boring because it is straight forward” [Student 40]. For two students out of the 50 (4%) timing was an issue. They stated, “I felt under pressure during exam times” [Student 15], and “I didn't like the time frame we had to complete some of the layers” [Student 58].

The eight out of the 50 (16%) of the students from the Open-ended Survey (based on the interview questions) that said no to having a choice making science more enjoyable responded with different ideas. These included, “I would rather do more focussed sheets” [Student 17]; “I don't really like doing homework for any subject” [Student 51]; “I don't mind doing any kinds of activities” [Student 7], and “Just because I'm not interested in studying science” [Student 1]. Another student commented, “I think science is really difficult for me” [Student 46]. (This was from a second language student.)

The findings from the Open-ended Survey (based on the interview questions) showed for six out of the 50 students (12%), time constraints were still an issue, four students out of the 50 (8%) did not like writing activities, and two students out of the 50 (4%) did not like homework. A further 12 out of the 50 students (24%) did not like the

research component. Comments made by the students included: “I chose activities that were more time consuming” [Case study 1]; “I learn better when working with someone else” [Student 26]; “Too much writing” [Student 34].

On average 98% of students enjoyed the units overall. They liked the hands-on activities, the research, computer based activities and working in a group. By being able to choose the activities, they wanted the work became fun to do, interesting, helped with learning, and was easy and visual.

4.3 Student achievement

This section reports the analysis of the data used to answer Research question 2, which asked:

Can the use of a Layered Curriculum approach to differentiated learning lead to enhanced student achievement?

Achievement data collected from the 70 students at the beginning and end of the intervention, in addition to information gathered using the case studies ($n=11$ students) and Open-ended Surveys ($n=50$ students), were analysed to examine whether student achievement had improved.

As a first step, examination results, collected at the start of the intervention were noted. Once the course was finished student grades based on their final examination results, were noted again, the results for which are reported in Table 4.4.

Prior to the intervention, 34 of the 70 students (49%) were awarded a C grade or higher. At the end of the intervention; however, 57 of the 70 students (81%) were awarded a C Grade or higher. These scores indicate that students were achieving at a higher level than before the course started. A pair sample test showed the p-value as less than 0.05 showing there is a statistically significant difference between the mean grades before and after the intervention. The Paired Samples Statistics data revealed that the mean grade after the intervention (71.96%) was greater than the mean grade before the intervention (58.83%) showing a significant increase in the students' results.

The results were further analysed to see how the students' grades had change over the duration of the intervention. Of the 70 students, 23 had improved by one grade, 16 students had improved by two grades, 10 had improved by three grades and three students had improved by four grades. There were students from the whole spectrum of grades (e.g., A* through to U) who improved their achievement score one-step (e.g., from being awarded a U to a G). The students who improved two steps (e.g., from being awarded a D to being awarded a B), were mainly from the upper band with 10 of the 16 students going from a D to B; C to an A; or B to an A*. Interestingly, five of the 70 students who were failing prior to the intervention (with a grade of E) improved to a C (a pass grade of between 60-69%) after the course.

Of the 70 students, nine remained on the same grade. It should be noted, however, that seven of these nine students were awarded a B (scoring 80 to 89%). The remaining four of the 70 students all went down either one or two grades.

Table 4.4 *Number of student awarded each grade before and after the course*

Grade level	Number of Students Prior to Intervention	Number of Students After Intervention
A *	2	11
A	8	15
B	15	17
C	9	14
D	10	6
E	16	4
F	8	1
G	1	2
U	1	0

n=70 students

To determine why student's achievement improved, interview questions and Open-ended Surveys were used. Questions in the interviews and survey sought to determine whether students felt that the intervention helped them better understand the work.

Responses to the Open-ended Survey (based on the interview questions) indicated that 32 of the 50 students (64%) felt that having a choice of activities during the intervention helped them to understand the work better. Nine of the 32 students (28%)

felt that having a choice of activities gave them control over their learning. One student commented, “I do what activates I want and I’m not forced to do anything” [Student 22]. Another said, “Because I can do the activities in the way I want means I will enjoy them more and spend more time doing them” [Student 37]. One student said, “When you do different things you approach it from a different angle so you think about it more so you engage more” [Student 7]. Five of the 32 students (16%) felt that, by having a choice of activities, the work was more enjoyable. For example, one of the students stated, “I think the activities are more interesting than reading and writing, so it can help me to understand the work better” [Student 46]. Another five of the 32 students (16%) felt that having a choice of activities helped them to relate the work back to their learning style.

To this end, one of the students stated, “I could understand more by putting the information into a presentation form that suits my style of learning” [Student 48]. Another student stated, “Being able to do experiments and project work definitely makes me interested in science, because we have choices to choose from to cater for our learning styles” [Student 43]. Five out of the 32 students (16%) found it more enjoyable and so learned the work better; with one of these students stating, “Because I am passionate about it and will have fun doing so it will stick in my memory” [Student 39]. Three out of the 32 students (9%) felt it reinforced the work more. For example, one of the students stated, “I’d say it reinforces the stuff we do in class and then with things we haven’t done, which are in different layers like the A-layer-that’s like something new to learn so it allows you to learn the basics again so it reinforces it” [Student 9]. Another student said, “It reinforced the work. Instead of studying you do these PowerPoints and stuff and it helps you remember” [Student 23]. One student said just by having the choice made the work easy to understand, “Something's I do I don't understand at all, but I can just choose an activity I do understand” [Student 30]. Four more students out of the 32 (13%) felt that knowledge was improved, with one student stating, “As it explores more areas of science” [Student 13].

Students who were unsure about whether having choices enabled them to understand the work better tended to feel that this was not always the case for five of them. One stated, “I understand the work as long as it's clear, but certain things make me understand it better than others” [Student 52]. One student felt that what they were

doing meant the depth of learning was not sufficient. That is, by doing activities might restrict the student from covering all of the content. For example, the student stated:

Because there are different activities that are not all the same. It helps you in some areas that you might need to go over. Let us say, for example, the A-layer there is one on fission and fusion, one on salts and the dangers of magnesium. You are only going to learn about one of them if you do one A-layer activity [Student 3].

This student was referring to only being able to choose one research topic from the A-layer and on speaking to the student further, he wanted to be able to choose to do more than one research topic. Another student stated, “I’m not sure it makes me more knowledgeable on the topics, but it does make it more interesting” [Student 34].

Of the 50 students, four (8%) did not feel that the activities helped them to understand the work better for variety of reasons. For example, Student 18 stated, “Experiments do not always give me knowledge on their own.” Student 19 said, “I don’t learn like that and I dislike doing the layer sheets.” One student stated, “Sometimes the textbook has more detailed explanations” [Student 15]. This particular student liked your more traditional work from the textbook type of learning as he thought it “created useful study material.” Student 14 stated, “It lets me choose things to work on that I already partially know and then I don’t have to study things I don’t know about.”

Ten of the 11 case studies demonstrated that differentiated programs of work lead to enhanced achievement levels. A paired sample test-test also revealed the p-value as less than 0.05 showing a statistically significant difference between the mean grades before and after the intervention. Case study 3 demonstrated that a layered approach to differentiated learning lead to enhanced student achievement. She very quickly wanted to earn A grades in her assignment work as she thought she could get the points that she needed to achieve this. In terms of her examination achievement levels at the beginning of the unit, she was achieving a D grade. By the time, she finished the course she was working at a C level. Case study 3 thought the work was “easy to complete.” She felt having a choice of activities helped her understand the work better. “You can do it in a way that makes it easier for yourself.”

Case study 7 quickly discovered that if she completed the work she performed better, which she was able to do, since she could choose what she wanted to do. Her aim in the assignments was either to achieve an A or a B grade, which she achieved in all five units. In terms of her examination achievement levels at the beginning of the unit, she was achieving an F grade. By the time, she finished the course she was working at a C level. From what the researcher observed Case study 7 realised that if she completed the work then she performed better. She felt having a choice of activities helped her understand the work better as she liked rewriting things she learned from the textbook. “It helps me to learn because I write down things and it helps me remember” [Case study 7].

Case study 8 found that a layered approach to differentiated learning lead to enhanced student achievement. By the time this student completed the course he had gone from not completing the assignment to achieving a D grade by the second one then on to A’s and B’s in successive work. In terms of his examination achievement levels at the beginning of the unit, he was achieving a G grade. By the time he finished the course he was achieving E’s in his examinations. Case study 8 felt having a choice of activities helped him understand the work better and it did not matter what activity he chose he felt he could still learn the same material. “If you do one thing it will still give the same understanding. It doesn’t matter what you choose you could still learn the same thing.”

Case study 9 very quickly went from a D grade in the first assignment to A’s and B grades throughout the rest of the work. In terms of her examination achievement levels at the beginning of the unit, she was achieving an F grade. By the time, she finished the course she was working at a D level. Case study 9 realised if she completed the work to a high standard then she understood the concepts. “They would be to a high standard and I would understand it better” [Case study 9]. She felt having a choice of activities helped her understand the work better. “I can choose which ones I do and what is relevant to me” [Case study 9].

Case study 10 was one of these students who showed good value was added to his learning. He very quickly went from not completing the first assignment to A’s and B grades throughout the rest of the work. This student struggled in science subjects. At the beginning of the course, he was working at an F level of achievement. He had been

shown previously to be a person who did not complete homework. He soon found that he could be successful early on in the course. Case study 10 very quickly realised that the work was something he could do and he decided that he could achieve at a higher level. This student completed the course with a D grade in his final examination, which was an incremental improvement that was driven by Case study 10, himself.

Case study 11, prior to the start of the course this student demonstrated an inconsistent attitude to homework. The work was either incomplete or of a low to average standard. The first differentiated unit was not fully completed either. He did not meet his goal to complete it because he gave up on it. He felt it was too demanding for him even though he found that it was fun. After that, he very quickly went from not completing the first assignment to A's and B grades throughout the rest of the work. In terms of his examination achievement levels at the beginning of the unit, he was achieving an E grade. By the time, he finished the course he was working at a C level. He felt having a choice of activities helped him understand the work better. "You can basically pick the most optimised one for you so you don't like not do it" [Case study 11].

Case study 5 claimed that a layered approach to differentiated learning did not lead to enhanced student achievement, as it was irrelevant. He considered the activities that he chose to do to be outside of the choice yet by their very nature was allowing this student to learn according to his learning style. Case study 5 always did the minimum amount to achieve his A grade. This was something that came easy to him. He was easily bored and went through what he termed the mundane tasks more out of habit to get the job done. Once he latched onto something that did interest him he ran with it and produced amazing work with high level thinking going beyond the expectation.

Overall, the results indicated that the use of a Layered Curriculum approach to differentiated learning lead to enhanced student achievement. This is discussed further in Chapter 5. The next section presents the findings for resilience, personal agency and self-efficacy.

4.4 Self-regulation, personal agency and self-efficacy

This section reports the analysis of the data used to answer Research question 3 that asked:

Can differentiated programs of work encourage students to self-regulate allowing students to have a sense of personal agency, as well as levels of self-efficacy?

This section describes: the results of the Open-ended Survey (based on the interview questions); the case studies relating to self-regulation (Section 4.4.1) and observations of the researcher as a participant observer relating to personal agency (Section 4.4.2); and self-efficacy (Section 4.4.3). This data was collected in response to research question three.

4.4.1 Self-regulation

For the purpose of this study, self-regulation was defined as the ability that students have to monitor their own behaviour, relating behaviour to both environmental effects and the way they have been brought up and self-reaction (Bandura, 1991). According to Bandura, 1991 self-efficacy plays a part in self-regulation, as well as personal agency. People hold beliefs on themselves and what they can do, setting goals to achieve the outcomes they desire. Students who are effective at self-regulation are able to adjust the way they do things according to the current task (Greene, & Azevedo, 2011), including persisting on tasks even if they are not enjoyed. The data collected from the 70 participants was analysed and examined to determine whether the differentiated units were effective in terms of encouraging students' self-regulation. This section starts by describing the work ethos of the students before the intervention and the main types of problems that the students faced during the intervention. It then goes on to examine whether the students overcame these problems during the five units to show whether they were able to adjust to the way they do things, as well as persisting on tasks even if they are not enjoyed.

The students demonstrated prior to the intervention that homework was something that was not always completed or handed in on a regular basis. Class work was often not completed to a good standard as determined by the teacher. This was an issue for 50 out of the 70 students (71%). For 34 out of 70 students (49%) homework was generally

not done at all, or done very poorly. For 21 out of 70 students (30%) before the intervention gave negative responses when they were asked to comment on science being enjoyable. Comments generally centred on wanting: less tests; less work; less writing and definitely no homework. One student stated, “I do not like boring book work” [Student 51]. Another responded, “Science would be more enjoyable if we did less work at home” [Student 36].

Students showed an improvement in their ability to self-regulate in a number of different ways including completing set tasks, generally overcoming problems and setting goals. This section will present the findings on the numbers of students completing each unit, the types of problems they faced and how they overcame these problems. The findings for goal setting is presented in Section 4.8 as part of another research question.

Over the five units, the numbers of students completing the work generally increased with an average of 82% completing the units as shown in Table 4.5. Smaller numbers (58%) completed the first unit but as time went on the numbers completing the units were steadily higher.

Table 4.5 *Numbers of students completing each unit*

Unit	Numbers completing the unit
1	34 (58%)
2	54 (92%)
3	51 (86%)
4	48 (81%)
5	55 (93%)
average	48 (82%)

n=59

During the differentiated units, the students described the main problems they faced were: time management; technical difficulties involving the computer; motivation; understanding what to do; and finding and reading articles in the A-layer. The numbers facing these issues over the five units are shown in Table 4.6.

Table 4.6 *Main types of problems faced by the students over the five units*

Unit	Numbers of students facing the problem				
	Time management	Motivation	Computer issues	Understanding what to do	Articles
1	10 (17%)	03 (05%)	01 (1.7%)	03 (05%)	04 (07%)
2	10 (17%)	06 (10%)	01 (1.7%)	04 (07%)	03 (05%)
3	07 (12%)	01 (1.7%)	01 (1.7%)	01 (1.7%)	02 (03%)
4	02 (03%)	00 (00%)	01 (1.7%)	01 (1.7%)	02 (03%)
5	03 (05%)	01 (1.7%)	01 (1.7%)	00 (00%)	02 (03%)
average	6.4 (10.8%)	2.2 (3.7%)	01 (1.7%)	1.8 (03%)	03 (04%)

n=59

When interviewed at the end of the intervention the students involved in the on-line survey (*n*=50) and the case study students (*n*=11) corroborated the findings. They stated the main types of problems they faced over the 12-month period were: time management; difficulty with the articles for the A-layer assignments both finding them and being able to understand them; getting motivated at the beginning of the unit at times; technical issues, sometimes not enough choices; and not understanding what to do. The results of this interview data are shown in Table 4.7.

Table 4.7 *Main types of problems faced by the students*

Types of problems	Number of students with the issue
Time management	15 (25%)
Difficulty with the articles for the A layer	07 (11%)
Getting motivated at the start of the unit	10 (16%)
Technical difficulties	05 (08%)
Not understanding what to do	11 (18%)
No issues	13 (21%)

n=61 students

Analysis of data gathered from the students who responded to the Open-ended Survey (*n*=50) and case study students (*n*=11) as well as observations by the researcher as a participant observer of all of the students (*n*=70) suggest that, throughout the intervention, students were generally able to address any issues and find ways to overcome them. These students generally showed their self-regulation changed and improved over the five units. The following sections go on to describe each of the problems the students faced and how they overcame them starting with time

management (Section 4.4.1.1), difficulty with the articles (Section 4.4.1.2), motivation at the beginning of the unit (Section 4.4.1.3), technical issues (Section 4.4.1.4) and not understanding what to do (Section 4.4.1.5).

4.4.1.1 Time management

Time management was reported to be an issue for 10.8% of the students on average from the five units although a greater number (25% of the students) on interviewing stated that time management was an issue for them on reflection. See Table 4.4 and 4.5. Time management generally, improved throughout the intervention with 17% of the students having this as an issue for the first unit down to 5% by the end of the intervention.

Being organised to hand in work on time tended to be the main issue around time constraints. In an example, the student-expressed difficulty in being organised, in terms of time, during the first two units when the students were required to make a video on the research, stating:

Going back a couple of assignments when we had to do the videos it was quite hard to organise. I do not think we had the time to do it and I do not think it reinforced it as much as writing it down would [Student 9].

This student went on to say the time issue was solved by completing extra work at home stating, “If we didn’t finish it on time we did it at home” [Student 9]. The researcher observed this student worked hard to ensure the remainder of the units were completed and was therefore better at resolving the issues over the five units showing she could adjust how they did things to complete the tasks.

Case study 8 prior to the start of the intervention was scoring less than 30% in school assessments and examinations. He had a history of being disorganised prior to the start of the intervention, which meant work was often not handed in on time, not completing class work and not completing homework. Case study 8 stated:

Yes. A few problems with organisation, which meant getting things in on time was difficult. Like if, it is technology there could be

something that goes wrong like not saving the file or if it is paper then if it is like writing or drawing that could get lost as well. I had no problems with the work itself.

This student would choose another activity if things were not going right with the first one. Case study 8 said, “If I had something go wrong then I could choose to do a different project.” He also stated:

At the start, I was not certain how good I would do but at the end, I was completing everything. Having good quality work is another important thing. I tried to do both of those. It was more points involved. I loved it and would recommend it to people [Case study 8].

This student kept on trying to do better at the assignments despite starting the intervention with a low grade consisting of a G. As time went by, he noticed his marks were getting higher and he was achieving better with a final grade of an F 10% higher than at the start of the intervention. “I achieved my goal by doing all of the tasks that I was familiar with, and used techniques and media that I already had background knowledge on how to use.” This student was able to self-regulate by using goal setting and adjusting how he did things.

Student 3 explained that time management was the hardest aspect to overcome as he had to work in with other students. This was often time consuming, as everyone had to agree on what he or she were doing. This student stated that he was better at doing one larger activity rather than trying to complete lots of smaller ones as he had difficulty with co-ordinating the little activities with others. This student responded:

The hardest part was time management getting the assignments done and working in with others. The problem with the videos and stuff like that was communication between the people doing it. I find that I am better with the larger assignments like the A and B-layer rather than the C-layer, because I have trouble co-ordinating the little things, whereas with one big thing I just do it all at once anyway [Student 3].

The researcher observed this student was more likely to get the work done if he chose to do the larger activities, rather than trying to do a large number of smaller ones. He managed this to some extent but did not always finish everything so was able to self-regulate to some extent. Case study 5 often had issues with time constraints due to the amount of time he took to do some of the activities, as described in Section 4.2. “Sometimes time constraints, but that is mostly self-imposed due to the amount of time I put into certain things” [Case study 5]. He commented he did not really over-come this problem of time issues and said, “I didn’t really. I just devoted more time” [Case study 5]. This student was able to adjust how he did things.

4.4.1.2 Difficulty with articles

An average of 4% of the students stated they had difficulty with finding and reading the articles for the A-layer throughout the units. The students interviewed later also stated this was a problem, but on reflection 11% of the students interviewed experienced difficulty with the articles for the A-layer (the research component) as the articles were either difficult to find or hard to read. One student stated, “For some of them I couldn’t find enough articles. They weren’t relevant and doing the video was hard to organise time wise” [Student 23] and for another, “Some of the A-layer was hard to find the information and you didn’t know if the information was reliable or not or really scientific” [Student 7]. The students who had difficulty with finding the articles either asked the teacher, or did not really overcome the problems. Therefore, these students showed self-regulation to some extent.

4.4.1.3 Motivation at the beginning

An average of 3.7% of students had trouble with motivation at the beginning of the units. The students who were later interviewed stated that motivation was an issue for 16% of the students overall. The C-layer was the basic skills layer, which eight out of the 61 students interviewed, did not like completing as they found it boring. This led to difficulty for students to motivate themselves to start this section. One student stated, “I think the main problem was staying focussed at the start of each assignment” [Student 6]. This student stated, “This improved as you got into the assignments, and resolved the problem. It was at the start of the assignments then as you get into the harder stuff you focus more” [Student 6]. Another said, “That I couldn’t get motivated

to do them, because I wasn't interested in the subject" [Student 37]. This student resolved this problem, "I just thought about it and looked up things and got it over and done with." This student was able to persist with the tasks even if they were not interesting to do.

4.4.1.4 Technical issues

Five students out of 61 (8%) who were interviewed stated they had technical issues resulting in difficulties with computers or the internet as shown in Table 4.4. These same students stated they had issues over the five units. For example, one student found it difficult to complete the requirements because of technical issues with computers, commenting, "Sometimes I had to complete three within a limited time, which was hard for me because I don't always have internet available". However, this student surmounted this problem by pushing herself: "I worked hard and pushed myself to finish on time" [Student 33]. In doing so, the student overcame the issue and made sure she completed the rest of the units on time. She stated, "I spent a lot of time on the assignments and got good marks in the end."

Student 59 stated, "I was sometimes unable to use internet at home, so I did the assignments at school and during class times." By doing the work at school, this student overcame the issues with the computer and was able to complete all assignments on time. Case study 7 at the beginning of the intervention had an aversion to computers. She stated, "I didn't like using computers as they take a long time. Sometimes they don't work or print etc." These reasons have often put her off doing computer-based activities. By the time, she reached the fourth unit she got interested in creating webpages so overcome her computer dislike. "I like making the websites because it was fun and different." By the time, she completed the last unit she was keen to do computer-based activities saying:

It helps me to learn because I write down things and it helps me to memorise. I enjoyed doing the webpage, research, database activity and the PowerPoints. I like these ones because they are enjoyable and I learn lots from them [Case study 7].

Case study 9 liked to make webpages from the second unit and said, "I chose to make the website as I love using computers and being able to change details without ruining

an assignment.” She found she often had difficulty with the webpages not saving when she was using Weebly. She said, “One problem I encountered was Weebly didn’t always work. The webpages didn’t always save.” She decided the best way to overcome this problem was to “I would usually when I emailed it to you [the teacher] I would save it on the email and then delete it off the account so I had enough space to save it.” This seemed to work for her and she had no more problems with Weebly saving. These students showed the ability to self-regulate by adjusting how they did things, or persisting on tasks they did not at first enjoy.

4.4.1.5 Not understanding what to do

The last problem faced by an average of 3% of the students over the five units was the difficulty of not knowing what to do at times. See Table 4.3. On reflection, 18% of the students interviewed stated that understanding what to do was an issue for them at times. These students would ask someone to help, generally the teacher or asked someone else they knew could help them out. One student stated, “That sometimes I had trouble understanding what was being asked of me” [Student 56]. The student further commented, “I overcame these problems by looking them up, asking the teacher or even asking another adult at hand or someone in the class who understood.” Another student said, “I had some problem because some work I do not know how to do” [Student 46]. This was a comment from a second language student. She overcame any issues by “I just find the answer to the question on the booklet or I can ask people who can speak Chinese with me” [Student 46].

Thirteen students out of 61 (21%) felt they had no problems to overcome, and as one student said, “I don’t remember having any problems with it” [Case study 10]. One student stated, “They weren’t that hard so I didn’t have any problems with it” [Student 14]. Another student stated, “I did not really have any problems as I could adapt what I was doing and find creative ways to overcome it” [Student 41]. By being able to adapt what she was, doing meant she was showing the ability to self-regulate. Case study 1 generally said she did not experience any problems stating, “Not generally. A few things were a little harder, but you could pick the ones you wanted to do.” Case study 1 stated that she learned from the problems she had. She felt that new problems would arise during other activities and that she was able to “deal with them accordingly.” She commented, “Problems are always going to present themselves but

there is always a way to overcome them.” Therefore, in that regard this student did not feel she had any issues.

Overall, the students did not encounter too many problems throughout the course but when they did, they were generally able to overcome them. Problems tended to include time management, difficulty finding articles for the A-layer, motivation at the beginning of the unit, technical issues and not understanding what to do. Students who were able to overcome these problems would ask someone or time manage better. Six of the 11 case studies indicated they encountered some problems. Case study 1 had time constraint issues especially around critical times such as examination sessions where it was hard to concentrate on activities. Case study 9 also had the same issue with time constraints but would persevere. Case study 5’s problem with time constraints was self-inflicted as he chose to produce amazing animated PowerPoints and a marketable game, which took him hours and hours to complete. He was highly motivated to finish them so just kept on going until he completed them to his satisfaction. This student demonstrated he had the ability to self-regulate. He felt time constraints were his biggest issue, but these were self-imposed to allow him to complete the activities that he wanted to do in the time available. Case study 5 spent a considerable amount of time on producing the game and the animated PowerPoint on rates of reactions. He was motivated to keep working on them until he had finished them, “I just devoted more time.” He also found some of the activities to be monotonous particularly in the C-layer, but would complete them anyway as he wanted the A grade. Case study 5 proved to be adaptable, as he would come to the researcher regarding an idea he had for an activity and would then proceed to complete the activity, spending a lot more time on it that was expected. This student generally expanded on what he had to do and extended it

Case study 9 also did not like it when students did not pull their weight and left the job to one or two people. Case study 9 got around this by choosing to work on her own. Case study 2 had an issue with homework, but she persevered with the work, as she knew to get the grades she wanted she would have to get on with the job at hand.

Over time Case study 8 showed tremendous improvement, both in his attitude to work and the effort he put into the activities. Homework was not always his strong point as he had a history of not finishing his work prior to the course starting. Whilst he did not

fully complete the first assignment, he managed to complete everything else very soon into the course. This had a major effect on his grades.

Many of the students were able to figure things out for themselves. Case study 3 was one of these students who persisted with the issues and did more research until she figured it out. Case study 5 and Case study 9 were also adaptable, as they would take an activity and mould it to suit what they wanted to do. This way the activities were flexible to cater for all styles of learning.

The results of the survey and case studies showed differentiated units of work allowed students to show an enhanced ability to self-regulate by completing set tasks and overcome any problems they may have had. The problems they faced were time management, difficulty with the articles, motivation at the beginning, technical issues and not understanding the work. The numbers with these problems generally decreased over the five units showing an enhanced ability to self-regulate. The next section will present the findings relating to personal agency.

4.4.2 Personal Agency

It has been well documented that education in the 21st century should be moving away from the teacher directed learning known as education 1.0 and from education 2.0 where web 2.0 tools are used. But instead to a more student centred approach known as education 3.0 where learners are involved in creating collaborative knowledge and therefore taking control of their own education (Buntting, MacIntyre, Falloon, Coslett, & Forrel, 2012). According to their research, learning needs to be more personalised to cater for individual needs of the learner, so they can work at their own pace. “Students should have more control over, and take more responsibility for, their own learning” (Bevins, & Price, 2016, p.19). Personal Agency refers to the extent to which individuals are involved in their own lives (Thoits, 2003, 2006). In terms of this study, personal agency means the extent to which students have control over their own learning. Personal agency is also a part of a student’s ability to self-regulate. Over the 12-month period, continued observations and survey data revealed insights into student perceptions relating to personal agency. The following comments were made by the participants at various times during the five differentiated units or when

observed by the researcher. They will be discussed in Chapter 5, but are presented here as an indication of their own personal agency and the degree to which they were able to self-determine activity.

Students showed personal agency under a number of different themes: Not being forced to do something; get to be more involved with their learning; and more control over the choices. Typical responses related to not being forced to do something meant they did not have to waste time or do things they did not like. One student said, “So I don't have to waste time doing things I don't enjoy” [Student 56]. Another commented, “Because I don't have to do one thing I don't like. I could choose something I enjoy” [Student 30]. “It is good to have a choice instead of being told to do something” [Student 32]. One student stated:

I could do what work I wanted and I could extend on what I wanted, I found this more enjoyable as I was not forced to work on anything I did not like. This meant I could choose what I wanted to choose and was not pressured to do anything [Student 22).

Students get be more involved with their learning by choosing what interests them or enabling them to challenge themselves more. One student commented, “You get to choose what you like to do. It involves you more” [Case study 6]. Another stated, “It lets me choose what I want to do” [Student 42]. One student said, “You are not confined to one area and you can explore other interests” [Case study 4]. Another one said, “It means I can do the activities in the way I want so I will enjoy them more and spend more time doing them” [Student 37]. One student responded, “I might understand how to make a presentation over a poster and can chose what I might understand more or if I want to challenge myself more then, I can choose the harder one” [Student 41]. One student stated, “The fact that there were different ways to learn and you could choose your own” [Student 43].

Students also had more control over the choices of activities they decided to partake in the study. One student said, “I could understand more by putting the information into a presentation form that suits my style of learning” [Student 48]. Another replied with, “If I didn't know how to write an article page or essay page I could always do the children's book or make a poster” [Student 36]. One student said, “You can basically

pick the most optimised one for you, so you don't like not do it" [Case study 11]. "I could choose what I wanted to do whether it be an essay or experiment" [Student 18]. One student stated, "I liked being able to do a video and also bring an artistic influence over it and do a brochure" [Student 11]. Another student responded:

I chose activities where I could design what I wanted and chose details I wanted to do. There were enough choices because I could modify it to suit. I chose to make the website as I love using computers and being able to change details without ruining an assignment [Case study 9].

The students found having personal agency meant the activity was more enjoyable or enabled them to remember the work better. One student stated:

I found the ability to work independently or to co-ordinate with someone else made it more fun, so I seemed to enjoy it. Definitely, the choice of doing different tasks and not being stuck on one track was enjoyable. It gave you more freedom [Student 3].

While another said, "I could enjoy the homework I chose to learn about" [Student 33]. The students could also remember the material better for examination purposes. "In the last exam, by being able to choose what I did meant I remembered some of the things from the booklet. It was active learning" [Student 15].

"It helped make revision easier [this is in reference to being able to choose the activities they did]. In the beginning we picked the easiest things and now we pick the interesting things" [Student 23].

All 11 case study students demonstrated personal agency in a number of ways. As the units progressed, Case study 1 demonstrated an increased sense of personal agency. In the beginning, she chose activities that she was interested in and could complete. She also liked working in a group. She stated, "They were the ones that I could complete and they all interested me. I liked working with a partner as I like teamwork." She then moved onto activities that suited her stating, "I chose activities that were convenient, to my ability or capability and best suited to what I enjoy doing or creating." She then went on to choose activities that were more adventurous such as a song. She said, "I choose these activities as I felt like being more creative than usual. I enjoyed these activities the most and I was still learning at the same time." She also commented, "I

like being able to expand my knowledge and I was able to do that through this.” By the time, she completed the units she commented:

You can choose the activities that suit your learning style. You can choose activities that suit your interest, and what you enjoy creating makes a difference to your learning. It made you partake more in the work because you found the ones that suited yourself [Case study 1].

Case study 9 was another student demonstrating an increased sense of personal agency. She started by being able to meet her own goals by the second unit. She said, “I was able to meet my goal because I could create items how I wanted them. I could choose computer activities or hand-made or I could keep adding to webpages. I could do them by myself and get them done when I wanted, or I could work as a group.” She very quickly realised by the third unit that she could be as creative as she wanted, and she could adjust the activities to suit herself. She commented:

I could put notes in my own words. It was a chance to be creative and I could do it in my own time. You could make the activities suit what you wanted to do. I liked the layer assignment as you can control your own learning and choose how you want to do it [Case study 9].

By the end of the intervention, she had the following to say:

I could modify the presentation of an activity if it did not suit me. I like that we could choose which ones we did. However, it was also usually in the exam. I quite liked doing the webpages. They were fun. I get the choice for my learning styles because I can choose which ones I do and what is relevant to me [Case study 9].

Case study 1 liked to work in a group, as she liked teamwork. Case study 9 also preferred group work, as she liked to hear everybody’s opinion or point of view. She liked to be in control of her own learning.

Students could choose activities that were best suited to what they liked doing. Case study 1 in one unit felt like being more creative than usual and built a model. She enjoyed what she did and was still able to learn from the activity. Case study 5 liked to expand on what he had to do and then extend it further. This suited him better than

the more monotonous tasks he felt were in the C-layer. Case study 11 liked computer based activities as he was not keen on writing as did Case study 6, and Case study 4 liked to use her activities as study notes.

Students had control over whether they chose something they knew a little about already or something that was completely new to them. Case study 2 liked to learn new things as she found it interesting to do so. Case study 1 liked learning about new things as she liked being able to expand her knowledge and Case study 8, who often struggled in the past to hand things in, even enjoyed researching on a new topic. Environmental issues were often a popular choice as students could relate to this and often knew something about it before hand. Students would find such subjects topical as they were often in the headlines.

Case study 7 liked that she could get to do her own way of learning. She described many activities as being fun and valuable to her learning. From what the researcher observed of this student over the five units, she showed a reluctance at the beginning of the units to complete the work. Homework was not always completed at the beginning of the year either, but this improved throughout the year even increasing in the mark.

Case study 3 found by being able to choose the activities she was more interested in studying science as she could tailor it to suit what she liked to do. This put her more in control of her learning. She liked that she could choose which ones she did. She described many activities as being fun and interesting and they seemed easy to complete. This enabled her to use the activities as part of her study notes that she could use later on. “They help me during revision for my exams” [Case study 3]. She was also able to work in a group, which she liked to do. “It was good being able to work in a group” [Case study 3].

There was plenty of evidence to show that differentiated programs allow students to have a high personal agency and that students valued the ability to choose activities. This will be further discussed in Chapter 5.

4.4.3 *Self-Efficacy*

Self-efficacy is a belief in oneself to have the skills to complete tasks (Cobern, 2005; Zimmerman et al., 2000). In other words being able to produce the outcomes desired by the student and at the same time avoid the undesirable ones (Bandura, 1990; Thoits, 2003, 2006). Self-efficacy is also a part of being able to self-regulate.

Over the 12-month period, continued observations and survey data revealed the following student perceptions of self-efficacy and a link to personal agency as presented in the last section. Typical responses showing a belief in themselves were activities could be extended, new skills acquired, and goals achieved.

Students felt that activities could be extended. “I like having a choice, so I can extend on the subject I would like to, also it becomes more enjoyable” [Student 22]. “Because I was able to learn more about each subject than I usually would in a normal science class” [Student 48]. “It will always improve my knowledge on certain topics.” “Because I am passionate about it and will have fun doing so it will stick in my memory” [Student 39].

Students were showing self-efficacy when new skills were acquired “Showed my skill when doing the mini projects and improved my learning skill” [Student 22]. “I can successfully name the organs and talk about heart and lungs. Also, I can name the parts of cells and parts of blood” [Student 59].

Students were able to achieve their goals. “I achieved my goal by doing all of the tasks that I was familiar with, and used techniques and media that I already had background knowledge on how to use it” [Case study 8]. “I did all the assignments by myself” [Student 56].

Case study 1 showed having a differentiated program allowed her to show high levels of self-efficacy. She generally had a personal belief in her ability to complete tasks as she always aimed for an A grade. She achieved this goal “as I worked hard and completed all the tasks I needed to get the mark I wanted.” Case study 8 was a low

ability student achieving at a level lower than 30% at the start of the intervention. By the second unit, he was showing self-efficacy. He commented:

I chose to design and perform an experiment to show the effect of acid rain on buildings as I had done it before. I also chose to research the ozone layer with my friends. I did the article and a video. I liked making the movie, as I was good at it [Case study 8].

By the fourth unit, he was achieving to a higher level and had more confidence in himself. He commented, "I chose to do a webpage as it was fun and enjoyable to make. I also did research on Bucky balls, as I did not know anything about it. I completed all of the tasks including the evaluation and research" [Case study 8] Case study 10 is a male student who is currently working at an F level of achievement. In the first differentiated unit, he chose the activities that he thought "were the easy ones." Once he saw that he could achieve with the activities he started believing in himself. Case study 10 stated, "I want to earn as many points as the top student." He also sent emails, with questions about the assignment or his work attached, late on the weekends on a regular basis. At least a dozen emails were sent during this time. Case study 10 never really showed any enthusiasm for anything in the past. When he was handed the next unit he very excitedly asked, "Is this the point thing again? Oh good! I love that." Throughout the unit, he often emailed the researcher his work at all hours of the night. His goal was to try something new, which he achieved. It was the first time he had produced a crossword, which he thought, looked easy and not time consuming.

Other students were proud of their work and loved to have it displayed on the wall or in the school magazine. Case study 5 was very excited about the work that he had produced that he was constantly showing the researcher what he had done. He loved it when it was shown to the class. Case study 5 even showed off his work to a relieving teacher to seek approval from her. In the researcher's experience, this is unusual for a capable student to want to get feedback from a relieving teacher. They will usually wait until their teacher gets back.

Having a differentiated program allowed Case study 1 to show high levels of self-efficacy. She generally had a personal belief in her ability to complete tasks as she

always aimed for an A grade. The fact that she did not finish some activities was more an issue of time management rather than a belief that she could not do the tasks.

Case study 1 was also motivated to try out new things as she was hoping they would help her remember better. Case study 9 told the researcher “I am determined to get a C in the external examination. I am motivated to put in the effort to achieve this.”

These students were showing that differentiated programs effect self-efficacy. This section has presented the data for student resilience, personal agency and self-efficacy in relation to science and will be further discussed in Chapter 5. The next section presents the findings for subject selection.

4.5 Subject selection and career in science

This section reports the analysis of the data used to answer Research question 4 that asked:

Does the use of differentiated programs of work encourage students to select science in subsequent years leading to a career in science and to what extent do students know about science related careers?

This next section reports the results of analysis to examine whether the subject selection and career choices of the participants improved with the use of differentiated science activities. Pre-and post-data, collected from the 70 students using the science survey, interviews with case study students and observations were analysed to answer this question. This section reports the findings in terms of selection of science as a career (Section 4.5.1), the types of science careers chosen and named (Section 4.5.2) and the reasons why students were selecting science subjects the following year (Section 4.5.3).

4.5.1 Selection of science as a career

The findings from the Ideas in Science Survey indicated that, prior to the intervention, 34 of the 70 students (48.5%) were definitely choosing a science-based career. Of the remaining students, seven (10%) indicated that they might choose a science degree, two (3%) were unsure and a 27 out of 70 (38.5%) indicated that they definitely would not choose science as a career.

After the intervention 44 students out of 70 (63%) indicated that they would choose a science-related career with only 23 out of 70 (33%) indicating a no response. Table 4.8 shows this data.

Table 4.8 *Table showing numbers choosing science as a career before and after the intervention*

Science as a career	Yes	Maybe	Unsure	No
Before	34 (48.5%)	07 (10%)	02 (03%)	27 (38.5%)
After	44 (63%)	02 (03%)	01 (01%)	23 (33%)

n=70

These findings indicate that, at the end of the intervention more students indicated they would take science as a career than at the beginning of the intervention. The results indicated that 10 students out of 70 (14%) who had originally indicated that they would not choose a science-related career, had changed their minds and, at the end of the intervention, decided that they would select a science-related career. A further five out of 70 students (7%) who were originally unsure about whether they would pursue a science-related career indicated that they would and three out of 70 (4%) indicated that they might consider taking a science career when previously they were not. Overall, the results suggest that more students, than before the intervention, had made definitive choices about taking science as a career. By the end of the study there were more students opting for a career in science and were going on to university to take various science subjects. A Wilcoxon signed rank test revealed that the data was significant at the 0.001 level.

Case study 1 was a high ability student who was not sure if she was going to take science beforehand. Her TOSRA results indicated a reasonable desire at the start of the course to take science as a career but she did not show much of a desire in partaking in science activities in her leisure time. By the end of the course, she was definitely going to take science to university level and then onto a career in science although she was not sure which field she would pursue. Case study 1 was going to continue to take two science subjects in the following year.

Case study 2 is a high ability student who was taking three sciences just in case she wanted a career in science but was not sure if she did. Her TOSRA results showed a medium enjoyment of science and career interest with a low leisure score. By the end of the course, she wanted to have a science-based career but was unsure in what field. She was definitely taking chemistry, biology, and maybe physics.

Case study 3 was an average student who showed a lower interest in science for enjoyment, leisure, career and normality of scientists. She was definitely not taking a career in science at the beginning. By the end of the course, she was considering a career in psychology.

Case study 4 was a high ability student and despite showing, a high interest in science was not sure if she would pursue science later on in life. She was however taking three sciences before and will continue with these three in the following year. At the end of the course, Case study 4 decided she definitely wanted to be a doctor so would pursue the sciences further.

Case study 5 was a very high ability student taking three sciences. Surprisingly, he had a very low score for enjoyment, leisure, career and normality of scientists in the TOSRA results. He was, however, interested in science as a career both before and after but was not sure in what field.

Case study 6 was a moderately low ability student whose parents were making him take three science subjects. He wanted to be a Surveyor so was possibly thinking of a career in science. His TOSRA results show a mediocre view towards scientists as normal people and science for leisure with a slightly higher result for enjoyment and career interest. By the end of the course, he had decided to go into law or business and not science. Parents may have an influence on what subjects' students select but at the end of the day the student will ultimately make the decision on his own career choice.

Case study 7 was a low ability student who interestingly had high results in all four areas of her TOSRA results. She was taking two sciences at the time but was not considering a career at the beginning of the course. Case study 7 did want to work in the health or sport industry so knew she needed sciences to help her with this but did

not consider this a career in science. Later she decided that she would take biology as a subject the following year but was not likely to pursue a career in science.

At the start of the unit, Case study 8 indicated that he was not going to pursue a career in science according to the Ideas in Science Survey. However, he wanted to be an architect. He did not consider this a science related career. This student has now decided that he will take physics and mathematics next year with the hope of taking up a science related career involving architecture. This was confirmed in the Ideas in Science Survey he completed at the end of the five units. His low grade at the beginning of the course made it doubtful that he would be able to pursue this career but with the effort he has put into his work and the increase in achievement levels demonstrated by this student makes this goal more achievable.

Case study 9 was a low ability student with a very high interest in science for leisure, enjoyment, career and normality of scientists according to her TOSRA results. All the way through the course, she wanted to be a marine scientist and was planning to take two sciences the following year.

Case study 10 was a male student who showed a low level of ability. His TOSRA results showed an average enjoyment of science with a less likely chance of a career in science. He did not use science in leisure activities and did not view scientists as normal people. He indicated he was not going to pursue a career in science both before and after the course.

Case study 11 was a slightly below average student who showed high enjoyment and interest in science in all four scales on the TOSRA. He was taking three sciences and indicated that he would like a career in science beforehand, but was not sure in what field. By the end of the course, he wanted to be an engineer and would take physics at university.

So, eight of the 11 students (72%) were going to take science as a career. Out of the other three, one might be a Geneticist and the other two were definitely not taking science. Ability levels did not seem to come into their decision to take sciences further as students with a range of abilities were opting into the sciences. Students were

interested in the work as they enjoyed what they were doing more as indicated in the first research question.

These findings were later corroborated with the data from the online survey (based on the interview questions) and the case study students. When the 50 students were interviewed at the end of the intervention along with the 11 case studies showed 20 students (33%) were not going to take science as a career supporting the further reduction in science averse student career choices over time.

4.5.2 Types of careers chosen and named

Before the intervention, the 48.5% of students who were opting into a science related career were mainly looking at the field of medicine, veterinary science, being a scientist or an engineer. Thirty-two of 70 the students (46%) indicated that they would like to pursue these types of careers. After the intervention, although these science careers were still popular, the number of students opting to choose them changed slightly. Eighteen of the 70 students (26%) wanted to work in the health industry as a doctor, dentist, physiotherapist or psychologist etc. Thirteen students (18.5%) wanted to work as a scientist in research – physics, biology or chemistry related (e.g., marine biology), as an archaeologist or in an astronomy, related field and 10 students (14%) wanted to be veterinarians or engineers. This data was corroborated by the students participating in the Open-ended Survey (based on the interview questions) and the students involved in the case studies.

To examine whether knowledge of the different types of science-related careers improved because of the intervention, students were asked to name at least five science related careers before the intervention and name at least five science related careers after the intervention. Before the intervention, student's responses showed 59 out of 70 (84%) of students were able to name at least five science careers. The most commonly names careers were doctor and forensic scientist closely tied followed by chemist, biologist, physicist, science teacher, dentist, veterinarian, astronomer and scientist. The 70 students named 41 different science careers.

After the intervention 49 different science, based careers were named. Doctor and forensic scientist were still the top two named careers by students followed by

chemists, physicists, biologists, engineers, scientists, science teachers and veterinarians as before. Although larger numbers named engineers, chemists and biologists than previously. More students also named marine biology as a career. Dentists, microbiologists and astronomers were not named as often as previously. Other careers not previously mentioned earlier before the course started, but were named after included anaesthetists, environmentalists, zookeeper and radiologists. By the end of the intervention, more students could name science related careers.

4.5.3 Subject choices

The Ideas in Science Survey conducted at the beginning of the intervention showed 33 out of 70 students (47%) were taking General Science, which is compulsory. One student out of 70 (1%) was taking one individual science subject, 19 out of 70 students (27%) were taking two science subjects and a further 17 out of 70 students (24%) were taking three sciences.

For 47% of the student's General Science was compulsory. Other students had chosen to take science subjects for a number of reasons. Of the 37 students who had chosen to take science, 14 out of 70 students (20%) did so because they enjoyed the subject. One student said, "I enjoy learning these subjects. I find them enjoyable and interesting" [Case study 8]. Another one stated, "I find them interesting and want to learn about the world" [Student 15]. Another student commented, "When I was choosing them they sounded interesting and like something I could do and enjoy" [Student 24].

A further eight out of the 70 students (11%) chose science subjects for career purposes. One stated, "I want to be a doctor" [Student 8]. Whilst another commented, "Interesting and need them for the job I want" [Case study 7].

A further five out of the 70 students (7%) thought taking science provided more opportunities. One student said, "If you do science it can have a wide range of opportunities, if you don't you shut off some options" [Student 7]. Another commented, "Open to all possible future paths, get into a good university and gain knowledge that may come in useful in future life" [Case study 5].

Four more students out of 70 (6%) thought they were good at science. One student said, “I did well at them at Year Nine” [Case study 3], and two more out of 70 students (3%) because they wanted to have a “good understanding of all sciences” [Student 6]. Responses given by only one student included because their “parents” were making them [Case study 6], “I like to challenge myself” [Student 35], and because “there was nothing else to take” [Student 25].

According to the Ideas in Science Survey conducted at the end of the intervention 64 out of 70 (91%) of students, were going to take at least one science subject in the following academic year. Only six of the 70 students (9%) were not taking at least one science subject. The interview students corroborated the number of students taking science subjects the following year.

The 61 students who were interviewed, included the 50 students involved in the Open-ended Survey (based on the interview questions), and the 11 case studies. At the end of the intervention those students interviewed, who were taking at least one science subject, were asked why they were taking science subjects the following year. For 16 out of the 61 students (26%) they needed the science subject(s) for career purposes. Another 15 out of the 61 students (24.5%) enjoyed the subject. Ten out of the 61 students (16%) found science interesting. Seven out of the 61 students (11%) did not have a choice. Five out of the 61 students (8%) needed science subjects for university. Four more out of the 61 students (6.5%) thought the sciences helped with other subjects, and two out of 61 (3%) thought they needed to keep their options open, with two more out of 61 (3%) finding science fun. These results are shown in Table 4.9.

Students who responded to taking science for career purposes included, “I would like to be a vet and I need to take these” [Student 29]; “I need these subjects to be able to study medicine later on” [Student 59]; and “They are pure sciences that are needed for my future careers [Student 13]. Those that found the subject interesting responded with comments such as “Biology is my favourite and interests me the most” [Student 26]. Comments relating to university included, “I need these to take a science course in university as they are pre-requisites” [Student 53]. Other responses included to, “Keep options open” [Student 21], “Physics is useful for other subjects” [Student 43]; and “Closely related to maths” [Student 36]. “It was fun” [Student 49].

Table 4.9 *Numbers of students indicating main reasons to take science in later years*

Main reasons for students to take science later	Numbers
Career purposes	16 (26%)
Enjoy the subject	15 (24.5%)
Science was interesting	10 (16%)
No choice	07 (11%)
University	05 (08%)
Helped with other subjects	04 (6.5%)
Keep their options open	02 (03%)
Science was fun	02 (03%)

n=61

Nine of the 11 case study students two years later were still taking at least one science subject. Three of the nine students were taking three sciences, three more of the students were taking two sciences and the remaining three students were taking one science. Eight of the 11 case study students were taking biology.

The Open-ended Survey (based on the interview questions) consisting of 50 students asked a further question relating to whether they were going to take science at University level. The data showed that 37 out of the 50 were taking science to university level, as well as eight of the 11 case study students, making 45 out of 61 students (74%). Of the 50 students, seven were unsure if they would take science to university level (14%) and 6 out of 50 students (12%) were not going to.

This section has presented the data from the 70 students who participated in the Ideas in Science Survey with both pre- and post-test data relating to taking science as a career, the types of science careers available and why they were taking the science subjects the following year. Data was also presented on the extent that students knew about science related careers. Further corroboration is shown from the findings based on the Open-ended Survey (based on the interview questions) that 50 students participated in science subject selection for the following year and onto University level and perhaps a career in science as well as data from the 11 case studies. This section has presented the data for subject selection and careers in science and will be

further discussed in Chapter 5. The next section presents the findings for choices and learning styles.

4.6 Choices and learning styles

This section reports the analysis of the data used to answer Research question 5, which asked:

Do students perceive the choices prescribed for differentiated programs of work sufficient to match their learning styles, and do these choices reflect the types of activities the students then choose to do and what changes would they make to the activities?

This next section presents the findings from the Differentiated Unit Survey, the Open-ended Survey (based on the interview questions), the case studies and observation made by the researcher showing data collected on the choices in the differentiated units and the learning styles of the participants. These instruments reported on whether students indicated there were enough choices to match their learning styles and also looked at why the students chose the particular activities they did (Section 4.6.1). The Ideas in Science Survey reported on the popular types of activities before and after the intervention (Section 4.6.2) whilst the Open-ended Survey (based on the interview questions) reported on what the students would change (Section 4.6.3) and whether their choices reflected their learning style (Section 4.6.4). Observations from the researcher and data from the case studies are immersed in the findings.

4.6.1 Enough choices

These are the findings from the five differentiated units by the 59 students, who participated in all five units. The results show that students increasingly thought there were enough choices to suit their learning styles. The data is reported in Table 4.10.

On average 71.5% of the students stated there were enough choices to cater for their learning styles throughout the five units, as reported in Table 4.7. Two students stated, “There were enough choices as there were different ways to show my learning” [Student 33] and “There were plenty of varied tasks for specific learning styles” [Student 55]. Fifteen of these 36 (42%) students described them as being good

activities that were interesting and fun. One student stated, “There were lots of interesting things to choose from” [Student 32]. Four of the 36 students (11%) said there were enough choices for them to be creative with one student commenting, “There were lots of experiments and I prefer to make things than write” [Student 14]. Three out of the 36 (8%) students said they were easy to choose with one stating, “It wasn’t difficult to choose the activities as there were plenty of them” [Student 30] and another commenting, “I could choose the ones that I enjoyed” [Case study 10]. As the units, progressed students increasingly thought there were enough choices with numbers responding positively to the number of choices throughout the five units. Students reported:

“I could choose computer activities or hand-made, could keep adding to webpage” (Case study 9). “There was something I liked in all the activities” [Student 12]. “I always got to do what I wanted. I had a good choice” [Student 30]. Other comments included “Enough to choose and a few that were new and fun to do” [Student 26]; “Posters are my favourite presentation style as it caters to my learning style” [Student 58]. Eight out of the 11 case studies stated that there were enough choices to suit their learning styles.

Table 4.10 *Numbers of students indicating there were enough choices to cater for learning styles*

unit	Numbers indicating enough choices for each unit
1	36 (61%)
2	40 (68%)
3	43 (73%)
4	46 (78%)
5	46 (78%)
average	42 (71.5%)

n=59

The results from the 50 students involved in the Open-ended Survey (based on the interview questions) confirmed there were 42 students who thought there were enough choices to cater to their learning styles. As well, the seven of the 11 students involved in the case studies also thought there were enough choices. This made 49 out of 61

students (80%). Two of the 50 students (4%) thought there were mostly enough choices, three out of the 50 students (6%) were unsure and only three of the 50 students (6%) thought that there were not enough at all. Concerning the other four case studies, they stated there could be more choices available at times. Case study 1 said:

I found in some of the topics there were enough choices but in others, it would be more limited. For some there would be an activity I liked but the way you had to do it was maybe not what I felt would suit me [Case study 1].

Case study 5 commented:

Activity blocks there was not really choices that I would particularly like to have done. Other ones there were choices that I enjoyed doing so I ended up devoting more time to some activities and a lot less on others just due to personal preference. Therefore, I found that the selection, in some cases, there was something and in others, it lacked stuff that I would choose to do [Case study 5].

The remainder felt there were not enough choices at times and would have preferred more, which included videos and more computer work. One student said, “There was not enough computer work” [Student 6] and another stated, “I would like to see more audience interactive activities available for students to choose” [Student 16]. Students over the five units who said there were not always enough choices made the following comments: “Only one interested me the others took too long” [Student 43]. “I would have liked to make a movie for one of the sections” [Student 48]. “Some options provided choices that I liked compared to others but not overall” [Case study 5].

Generally, students found the choices to be enough to cater to their learning styles. The next section will describe the choices that tended to be more popular amongst the students.

4.6.2 Popular choices

The Ideas in Science Survey completed both at the start of the course and after the five units showed the findings that computer-based activities were popular. Computer-

based activities as a popular choice was also confirmed in the fifth unit. More students were producing webpages.

Experimental work was still a favoured activity as it had been throughout most of the units and the number liking doing research had increased slightly. In the same survey both experimental work and computer based activities were what made science more fun.

4.6.3 Changes to the units

The following are the findings of the Open-ended Survey (based on the interview questions) that 50 students participated in relating to the choices of activities and the 11 case studies – a total of 61 students. The students were further asked what changes they would make and whether their choices reflected their learning styles. In response to whether any changes were needed for the intervention 17 out of 61 students (28%) felt that no changes were necessary, 40 out of 61 (65.5%) stated small changes were needed with 4 students out of 61 (6.5%) being unsure of what changes could be done. Of the 17 students who thought no changes were necessary, one student commented, “I think it is a really balanced program for people with different preferences” [Case study 8], with another stating, “The program was really good. I liked how it was set up” [Case study 6]. Other similar comments were “I found something that I like in every layer” [Student 14], or “I was happy enough with what was there” [Student 59].

The forty students who thought that small changes were needed in some areas came under five broad themes: changes to the A layer; changes to the structure of the layers; some larger activities, more of a specific type of activity; and more choices were needed. Table 4.11 indicates the results.

Four of these 40 students (10%) commented that changes needed to be done to the research section – the A layer. One student commented, “It would be better if articles were provided for the A layer so you could answer questions on it as it was difficult to find articles” [Student 11]. Seven of the 40 students (17.5%) suggested the way the layers were arranged could be changed.

If the C-layer were worth more points that would be better or if you could choose two A-layers instead of a whole pile of C-layer or something like that to total the number of points at the end. It would be better to get the points from any part of the assignment rather than having to get points from each section [Student 3].

“If you could do more from different sections rather than having to do so many points from each section that would be better. That way you could do three A-layers. Some C-layer activities need to be worth 20 points” [Student 6].

Table 4.11 *Numbers of students indicating the types of changes needed to the intervention*

Types of changes	Numbers indicating the change
A layer	04 (10%)
Structure of the layers	07 (17.5%)
Larger activities	04 (10%)
More specific types of activities	13 (32.5%)
More choices	05 (12.5%)
Other	07 (17.5%)

n=40

Four students out of the 40 (10%) thought that there could be some bigger activities instead of many smaller ones. One student stated, “Maybe having one or two big things instead of lots of small ones” [Student 27], and another said, “There could have been a few more, big group projects that take a while” [Student 34]. Thirteen students out of the 40 (32.5%) thought that there should be more specific types of activities including more practical work. As indicated in the Ideas with science survey experiments have always been popular throughout the course. One student said, “I would have more experiments because they are fun and help to learn in different ways” [Student 43]. “More experiments so we know what happens and learn it instead of being told it” [Student 19]. Another student who wanted more specific types of activities stated, “I like textbook type work but there were not a whole lot of textbook type questions” [Student 12]. Whilst another commented, “More crosswords would be suitable to cater for my learning style” [Student 18]. Five out the 40 students (12.5%) commented there were enough choices at times but not all the time. One student stated:

For certain activity blocks there was not really choices that I would particularly like to have done. Other ones there were choices that I enjoyed doing so I ended up devoting more time to some activities and a lot less on others just due to personal preference so I found that the selection in some cases there was something and in others it lacked stuff that I would choose to do [Case study 5].

Seven out of the 40 students (17.5%) had a variety of responses. One student said, “It would be good to have a variety of homework to choose from which also had different choices to cater for learning styles” [Student 33]. Another stated, “Maybe adding a topic that makes us learn more about the experiments history” [Student 48].

Students, overall, liked the activities and were happy enough with the choices available. Some changes to the intervention were suggested to help improve the intervention. These will be discussed further in Chapter 5. The next section presents the findings on whether the choices related to learning styles.

4.6.4 Choices relating to learning styles

The next question in the Open-ended Survey (based on the interview questions) related to the choice of activities and student learning styles that 50 students were involved with along with the 11 case studies. The researcher observed that students tended to choose activities that suited their particular learning styles. The students in their Open-ended Survey (based on the interview questions) reported that they tended to choose options that suited their learning styles. The 11 case studies also confirmed this. Typical responses to show students were choosing activities that related to their learning styles were as follows:

“Being able to do experiments and project work definitely makes me interested in science because we have choices to choose from to cater for our learning styles” [Student 43].

“I get the choice for my learning styles” [Case study 9].

“Caters for my learning styles. Whatever learning style you have is catered for” [Student 9].

“You can choose what suits your learning style better” [Student 5].

“Because we choose the activity which best suits your learning style” [Student 15].

“Being given a choice makes it more suited to different learning styles instead of just one choice” [Student 58].

“I think it is good that you get to do your own way of learning” [Case study 7].

The researcher observed that the small number of students who chose activities outside of their main learning style did not like the activities. These students described the activity as boring. One student chose to write an essay, but this was not from his main learning style. He was not keen on the activity but forced himself to partake in the work as he felt it was useful for him to study for his examination. He stated, “The essay I chose to do as it was helpful for study, but I didn’t enjoy as it took a while to do and was boring” [Case study 6].

Firstly, Case study 1 had a kinaesthetic and interpersonal learning style so tended to choose more interactive activities and liked to work in a group. She felt it was a good program and she would recommend it to others. Case study 6 liked how the program was set up and thought there were enough choices. He was a visual learner and tended to choose activities that suited that particular learning style. As he was examination orientated, he liked activities that would provide him with study notes. This student was also strong in musical ability but did not choose these types of activities, as they were perceived to be more difficult. Case study 7 was a reluctant learner and often did not complete homework. As a kinaesthetic learner, she tended to choose activities to suit her learning style. She felt there were enough choices to choose from and she particularly liked the B-layer. This student learned how to make web pages, which was a new skill for her. One that she really enjoyed and found a lot of fun to do. Case study 8’s learning styles involved visual and intrapersonal intelligences, so his activities tended to suit these learning styles preferring to work on his own or do activities such as web pages. He found there were sufficient choices throughout most of the units. Both Case study 2 and Case study 9 had a wide range of learning styles so any activity would have suited them. They both found there were plenty to choose from in each unit. In the unit. Case study 2 perceived the choices prescribed for differentiated learning activities sufficient to match learning styles throughout all of the units. She said, “There were plenty of options for us to choose” [Case study 2]. This student had a wide range of learning styles as indicated on the Multiple Intelligences survey, so

any activity would have suited her. She scored very high for both musical and kinaesthetic with a nine and 10 respectively with the other learning styles, except verbal with a four, scoring a seven or eight showing a moderately high interest in these types of learning. She tended to choose to produce PowerPoints, design experiments and write stories as well as a board game. “I chose those activities as they suited my learning style and were interesting” [Case study 2].

Case study 10 scored a 10 for intrapersonal on the Multiple Intelligences profile showing working individually is a high learning style for this student. Logical and verbal were a moderately high learning style for this student scoring seven and eight respectively. This student liked to work on his own and would choose activities such as PowerPoints and essays, which were more suited to his learning style. He scored a three for musical and never chose activities relating to songs or other musical activities.

This student perceived the choices prescribed for differentiated learning activities were generally sufficient to match learning styles throughout most of the units. According to the Multiple Intelligences profile this student scored eight for three of the learning styles: musical, interpersonal and intrapersonal and a seven for logical showing a moderately high level for these styles of learning. He tended to choose computer based activities such as PowerPoints and web pages and was happy when working in a group as these suited his particular learning styles. Kinaesthetic and verbal scored very low on his profile and he often stated, “I hate writing” or that he was not good “at presentation” [Case study 11].

Case study 3 had musical, kinaesthetic and interpersonal learning styles and chose activities where she could create things making it fun and easy for her. She felt there were enough choices to suit her learning styles but also tended to choose activities that were not musical. Case study 4 had a moderate to high leaning towards all the intelligences so any of the activities would suit her. She felt there were enough choices in the C-layer but not so many in A or B. She wanted options that are more practical. Case study 10 was a low ability student with extremely low scores for all the learning styles. Despite this, he was very motivated to do the work and liked making PowerPoints and doing experiments. He felt there were enough choices and he would not change anything. Case study 5 had a strong leaning toward verbal and intrapersonal

intelligences and loved to work on his own. He tended to choose to write essays or make PowerPoints, which suited his learning styles. Case study 11 showed musical and both interpersonal and intrapersonal intelligences. He tended to choose computer based activities and felt there were mostly enough choices. This student liked working in a group, which suited his learning styles although he tended not to choose musical activities.

4.6.4.1 Music as a learning style

One learning style that was a strength for 11 out of the 70 students (16%) was observed by the researcher as not being used to any great extent to choose the activities they would do. This learning style was the musical style. When asked why this was the case three of the 11 students (27%) responded that they did not like to use music to do the activities. Typical responses to support this were:

“I just liked listening to music but not making music with chemistry” [Case study 2].

“I don’t really use musical stuff to learn. I like writing things down” [Student 25].

“I’m not very good at writing educational stuff that is music related” [Student 24].

Four out of the 11 students (36%) commented that it was embarrassing to perform in front of the class with a musical activity. One student commented:

I enjoy music, but I do not have the will or dedication to practise music.

I would be too embarrassed to sing. My voice has broken, and I would die if I had to sing in front of the class. I would have made up a song if I did not have to sing it [Case study 11].

Another student said, “I didn’t want to perform the song. I would have done songs if I didn’t have to sing in front of everyone” [Case study 9]. Another stated, “Me and Case study 1 didn’t want to present the song so we didn’t choose music activities to start with. But we found it more helpful later on” [Student 23]. The other four of the 11 students (36%) stated that it was easier to do other activities, musical activities were perceived to be time consuming, the student was lazy and the last one preferred activities that are more practical. One student said, “It was easier to do other learning style activities such as the computer work. It was fun but more difficult to do. Maybe other learning styles would be more beneficial” [Case study 6]. Another commented, “To start with we thought creating a song might be quite time consuming, so we didn’t choose to do that initially. Then we discovered it was quite easy to do. It was fun. It

was interesting looking up rhyming words to go with it” [Student 9]. The third one stated, “I never made up any songs as I’m basically lazy. It requires effort to make up a song” [Student 3]. Whilst the last one said, “I didn’t use music as I like more practical stuff rather than theory. I think it could be useful to write songs to help with study though. I might take chemistry next year, as I like to read the chemistry information from the bottle. I find it really interesting” [Student 11].

From what the students told the researcher, they liked to listen to music, but were not keen on presenting an activity in a musical way. There were other easier ways of producing the work. This will be discussed further and explored in Chapter 5.

4.7 Higher level thinking

This section reports the analysis of the data used to answer Research question 6 that asked:

Do various forms of differentiation allow for higher level thinking for all students, as well as engagement and motivation, and what do students perceive to be improvements to the A-layer section of the differentiated program?

This section presents the findings of the effect differentiated programs have on higher level thinking and includes the types of activities found in the A-layer and whether they completed them fully, why the students chose them and whether differentiated programs allow for higher level thinking for students to be involved in. These findings are presented in Section 4.7.1. Additional questions were asked during the Open-ended Survey (based on the interview questions) and in the case studies relating to what they liked and did not like about A-layer and what they would change. These findings are presented in Section 4.7.2.

Students need to have higher order thinking skills as this is thought to be an important goal in education in the modern world (Holmes et al., 2015; Zohar, & Dori, 2003). A model developed by Bloom (Krathwohl, 2002) involved six levels of thinking. These are the knowledge level, the comprehension level, the application level, the analysis level, the synthesis level and the evaluation level. The levels involve remembering, understanding, applying, analysing, thinking creatively and then evaluate critically (McGrath, & Noble, 1995).

The differentiated units were separated into three layers to allow for different levels of thinking. The layers were the C-layer, the B-layer and the A-layer with all layers incorporating ICT, Gardner's Multiple Intelligences and Bloom's Taxonomy. The C-layer was the skills layer where students learned the main concepts of the topic and the activities related to the knowledge and comprehension level according to Bloom's Taxonomy. Students could then go onto the B-layer where students could choose activities that related to the application and analysis level according to Bloom's. The last layer – the A layer involved students researching and could choose activities relating to synthesis and evaluation according to Bloom's. There were three or four research question for each unit. The students could present in any manner according to their learning style or that they were interested in doing to achieve the required number of points. This could involve designing experiments and evaluating sources of error, creating a board game or researching topics and writing their opinions on their findings. Students involved in the five differentiated units reported their findings relating to higher level thinking in each of the end of unit surveys, as well as the students involved in the in the Open-ended Survey (based on the interview questions). These are the findings from this study relating to the range of topics chosen, why they chose the particular topic, whether they completed it and if they thought higher level thinking skills had been employed.

4.7.1 Choices of A-layer activities involving higher level thinking

The students had a range of topics to choose from in each unit from the A-layer section with the aim of extending their thinking. The numbers involved in choosing each topic is presented in Table 4.12.

Options involving environmental issues were very popular choices amongst the students over the five units. They looked at global warming and ozone, acid rain, heavy metals and deforestation with a total of 72 environmental topics chosen out of the 294 topics (24%). Nine out of the 59 students (15%) chose these topics because they related to the world around them as real issues. One student stated, "Wildlife interests me. The ecosystem is endangered due to human influence" [Student 55]. Another said, "It is an interesting topic happening now in the world" [Student 21], and "I like researching topics that are relating to the environment and us" [Case study 4]. Six students out of

59 (10%) already knew something about the topic with one stating, “I chose to look at global warming as I knew a little bit about it and it is topical” [Case study 2].

Table 4.12 *Numbers of students choosing each topic over the five units*

Topic	Numbers over the five units
Acid rain	20 (07%)
Crystals	15 (05%)
Drug testing	06 (02%)
Creating atoms	03 (01%)
Nanotechnology	04 (01%)
Explaining a microscope to an ESoL student	09 (03%)
Critique of an article	27 (09%)
Experimental design	09 (03%)
Global warming and ozone	23 (08%)
Periodic table	02 (01%)
Bucky balls	22 (07%)
Children’s book	32 (11%)
Spider silk	23 (08%)
Survey	01 (0.33%)
Bionic plants	03 (01%)
Deforestation	23 (08%)
Heavy metals	06 (02%)
Medicinal uses of nuclear radiation	22 (07%)
Fission and fusion	04 (01%)
Radioactive isotopes	05 (02%)
Electrolysis	06 (02%)
Life on other planets	16 (05%)
Space junk	05 (02%)
Science of superpowers	01 (0.33%)
Extraction of magnesium	01 (0.33%)

n= 294 (5*59 students)

For seven out of 59 (12%) it was a group choice with one of these students stating the topic also linked to other subjects. One student commented, “Global warming had links with other subjects I take so that was why I chose that option. I could also work on it as a group and we could all have an input on it” [Case study 9]. Seventeen out of the 59 students (29%) over the five units commented that looking at environmental issues was interesting with 15 out of 59 (25%) stating it was easy to find information. One student said, “I enjoyed designing and performing the experiments on acid rain and creating the PowerPoints. I found them interactive and exciting. I also liked the activity on global warming as I was interested in learning more about it” [Case study 1]. Another popular choice for students included activities that involved explaining

concepts to a target audience science such as how to use a microscope for second language students, or a children's book on the planets involving 14% of the students. They found this a fun way to show their understanding of the work and they could be creative. One student commented, "I like to draw and write stories" [Student 43]. Others stated, "It was fun to do something different" [Student 27] and "It was different to what I usually do" [Student 48].

The use of spider silk and medicinal uses of nuclear radiation were also very popular as they were interesting, and they could learn more about a topic they did not know much about. Twenty-three students out of 59 (39%) chose to research about spider silk in that unit. "I chose the activity on spider silk as I could do a PowerPoint related to Spiderman. It was interesting, and I like superheroes. I really enjoyed this aspect of the unit as I created a Spiderman themed PowerPoint" [Case study 5].

"PowerPoints are a great way to learn creatively and I had previously watched a documentary on spider silk which I knew nothing about" [Case study 4]. Twenty-two out of 59 students (37%) choose to research the medicinal uses of nuclear radiation. With 12 out of the 22 (54.5%) showing an interest in the topic as it related to medicine. Four of these students (18%) were thinking of becoming doctors. "I enjoy researching and expanding my knowledge, so this activity interested me" [Case study 1]. Another stated:

I chose to do radiation in medicine in the A section. It was very interesting, and I could relate it to a real situation. I completed every task and did a page on various types of treatment. Writing my opinion made me think about the topic otherwise I would just write it down and forget it. I enjoyed the medical part, as it was interesting and new. It made me think of future careers [Case study 2].

4.7.2 Completion of the A-layer

Students over the five units generally completed the whole activity in the A-layer with an average of 88% of the students completing the activities overall and showing a general increase in the numbers as the units progressed. The results are shown in Table 4.13.

Table 4.13 *Numbers of students completing the A-layer in each of the units.*

Unit	Number completing the A-layer
1	53 (90%)
2	44 (74%)
3	50 (84%)
4	56 (95%)
5	57 (95%)
Average	52 (88%)

n=59

The fifty students who were involved in the Open-ended Survey (based on the interview questions) and the 11 case study students (61 students) corroborated these findings. These students stated the majority of students managed to complete the required research in each of the five units with three students not completing all five and a further five students who were unsure. This meant 58 out of 61 students (87%) had completed the A-layer activities. Students who completed all of the A-layered research made these types of comments. One student said, “I did complete all of the A-layer activities and covered all sectors” [Student 18]. Another stated, “Because there were usually three options we normally had to pick one to do so I could finish it” [Student 48]. “I have done all of the A-layers and I wrote my opinion and did my presentation” [Case study 5].

4.7.2.1 Time constraints

Reasons given for not completing the whole activity were time constraints. They were required to produce a video for the first two units along with their findings. Students often ran out of time to complete this aspect with one student stated, “I did not complete the video. I ran out of time” [Case study 2]. For one student outside time commitments made it difficult to complete the work. “I didn’t finish the work due to outside time commitments” [Student 16]. In the first unit, only four out of 59 students (7%) liked making the video with one saying commenting:

I chose to design and perform an experiment to show the effect of acid rain on buildings as I had done it before. I also chose to research the

ozone layer with my friends. I did the article and a video. I liked making the movie, as I was good at it [Case study 10].

The video component was made optional for the last three units as timing was an issue and few students liked the video component. Students considered the video as reinforcing what they had already done and so was not necessary. One student commented, “I didn’t like the video presentation as I hate videos and I didn’t feel it was needed” [Case study 4].

The students involved in the Open-ended Survey (based on the interview questions) and the 11 students involved in the case studies confirmed this. According to the findings, these students reported not completing the research said that time was an issue. One student said, “Most of them we finished. Some we might have got half way and then run out of time” [Student 6]. “I complete most of the A-layer activities but missed a couple” [Student 19].

4.7.3 Higher level thinking

The A-layer section was designed to teach students to think critically. Several questions are posed so students can analyse a real-world issue. These issues do not have a clear solution so the research the student find can support more than one answer. Students research the topic to find out current information and then form an opinion on what they have found out. These are issues that can be debated, and students must take a stand on the issue.

The researcher observed the students found this a difficult process to do in the first unit. Students like to be spoon fed so they do not have to think for themselves. In the first unit, they were all required to go back to their research and expand on what they had written. As the students progressed through the units they learned to make a stand and state their opinion. By the last unit, the majority of students were managing this process and thinking critically about what they had written.

Using the Differentiated Unit’s Survey the students were asked whether the research made them think more about the topic they chose to research after each unit. An

average of 43% over the five units indicated the students were thinking about the research they were doing. The findings are shown in Table 4.14.

Table 4.14 *Numbers of students indicating they thought more about the topic*

Unit	Numbers indicated they thought more about the topic
1	04 (07%)
2	06 (10%)
3	35 (59%)
4	37 (63%)
5	46 (77%)
Average	26 (43%)

n=59

The findings indicated the students were thinking more about the research as the units progressed with 7% thinking about the work in unit 1 to 77% thinking about the work in unit 5. Students generally stated that writing their opinions forced them to think about what they were doing. As one student said, “I needed to think to write my opinion” [Student 55], or as stated by another, “I had to think a bit as I had to explain things [Student 59].

One student commenting on his acid rain research stated, “Researching made me think on the effects, how it can be stopped and how bad it actually is” [Student 10]. Other student comments supported this view as shown here: “I never understood acid rain before so researching it made me think about it more” [Student 17]. “I realised deforestation was bad and that we should stop or prevent tree logging” [Student 39]. “Researching made me read and understand the topic before commenting about my opinion” [Student 14]. “Putting my opinions made me think and create opinions. It challenges you” [Case study 4].

One student stated, “I don’t like summarising articles as I run out of things to say. But having to write the opinion does make me think about the topic as I thought about the uses of macromolecules” [Case study 3]. While another said, “While writing an opinion many questions came into my head” [Student 12]. One student said:

I chose to do the science of superpowers, as I was genuinely interested.
I completed a four-page essay, opinion based piece. Writing my

opinion did make me think about the topic but I was already thinking about it. I enjoyed the super hero research, as I was interested in it [Case study 5].

One student said, “It made me think of things I would not have thought of” [Student 48]. Another said:

I found the A-layer interesting and topical. Doing the assignment and writing my opinion made me think about what I was reading. Normally I would just read the article and not think about it [Case study 2].

There emerged two further themes from being forced to think. Firstly, thinking meant they either learned more or remembered more and secondly, they had to consider other points of view. Eleven out of 59 students (19%) that stated they learned or remembered more made comments that included the following. One student said, “I completed all of the A-layer on the environmental issues. Writing my opinion on the topic made me think more about it as I had to think about how I felt towards it which made me remember” [Case study 4]. Another student responded:

I completed the A-layer on endothermic and exothermic reactions as you could earn many points. Writing my opinion made me think about the topic more as just reading the information was not enough to write about. I had to research more in order to grasp the topic [Case study 8].

One student said, “I now know information I didn't” [Student 28], with another stating, “I understood what ultrasounds actually are” [Case study 7]. Another student said:

I did the research on nuclear fission and fusion. I did not know what nuclear fission was so I chose this activity. I enjoyed the research and doing the PowerPoints on topics I have never heard of. It was interesting. Writing my opinion made me think about the topic because it allowed me to learn more about the topic [Case study 10].

Three out of the 59 students (5%) commented that group work was good for doing the research as according to one student:

I chose to do the research on spider silk as I found it interesting. Writing your opinion of the topic made you think about it as it meant discussions could be had and you could hear others' opinions. I liked working in a group [Case study 9].

Another student stated, "It makes you more open to others' opinions and understand others' points of view more. It is clearer to read in an article instead of a textbook" [Student 11]. Another student said, "It made me revise what I wrote and what others in my group wrote" [Case study 9]. According to another student, "When I was researching, by looking at others' views, made me think more about it" [Student 40].

More thinking about their work was happening rather than just going through the process. Student 55 commented "I love it – the universe is so big it makes me wonder what is out there" while another stated, "They made me think" [Student 27]. One student stated, "By trying to explain this in a simpler way really made me think" [Student 58]. One student stated:

I enjoyed the A-layer, as it required searching and acquiring knowledge. I want to be a doctor and it interested me. I completed all the required tasks. Writing my opinion made me think about the topic, as you had to think and express your feelings therefore you had to think [Case study 4].

Students who felt they did not think about the research made comments such as the following. One stated, "I already had an opinion formed before doing the research" [Student 9]. Alternatively, as another student said, "It was easy to find answers on internet, so I did not need to think" [Student 4]. One student commented, "Writing my opinion didn't make me think about the topic, because I end up paraphrasing the article" [Case study 9].

Differentiation generally allowed Case study 1 to participate in higher level thinking activities. Researching the various topics and writing her opinion allowed this student to think more about what she was researching. She chose a variety of different topics such as methods of making crystals, global warming, spider silk properties and the effect of heavy metals on human health. She enjoyed researching the A-layer as it was

a motivator for her and “you could find out new things that you didn’t know about” [Case study 1]. She chose to research these as “I enjoyed researching and learning about new areas that I hadn’t yet before known much about. I like being able to expand my knowledge and I was able to do that through this” [Case study 1]. For most sections, she found the research to allow higher level thinking.

Case study 2 liked that she could relate to the research in a real situation. Case study 5 preferred the A-layer section as he often found the C-layer monotonous. He could get more extended information through his research and liked that he could adjust the work to suit himself.

Differentiated units allowed students to increasingly think about what they were researching as they were forced to think more. The units allowed students to regard others’ points of view as well as learn or remember more. The next section will present further findings on the A-layer.

4.7.4 Further findings on the A-layer

Further questions were asked during the interviews to the case study students and students involved in the Open-ended Survey (based on the interview questions) relating to what they liked and did not like about A-layer and what they would change. These are the findings from these students. When asked if they liked doing the A-layer questions 43 out of the 50 students (86%) indicated they liked at least some of them if not all. Eleven out of 50 students (22%) suggested they were fun to do. One student commented, “I just particularly liked doing the A-layered questions because I thought they were fun” [Student 14]. One student said the A-layered questions were good for the more-able student stating, “It was useful for extended students, those who understood the work” [Student 15]. Another student stated the A-layered section was good for points on offer as it was easy to manage getting the number of points you needed when the activity was worth more. This student suggested, “If I had the option, if I had to come to a certain amount of points and you had all of the big assignments I would do them instead of the little ones, because I have trouble managing to do them” [Student 3]. The 11 case studies also generally liked the A-layer questions as they could learn from the work. Case study 8 stated, “I didn't know anything about them.

Then writing your views on it. I really liked that.” Case study 5 said, “It definitely opened up thought processes. I think everyone should do something from the A layer due to the nature of it.” Case study 7 commented, “It was enjoyable, and I learned a lot from them.”

Only seven out of 50 students (14%) indicated they did not like this section. One student said, “I liked the fun ones; like making a book, but not really the research ones” [Student 55]. Another commented, “Because I don't think I learned anything from it” [Student 30]. “They were not focused on the stuff that we would actually be asked for the exam” [Student 17]. The end of unit surveys also showed these students were increasingly enjoying the research section to confirm what was being said in the Open-ended Survey (based on the interview questions).

The 50 students involved in the Open-ended Survey and the 11 case study students were asked what they would change about the A-layer. They gave a variety of different answers, but they came up under four broad headings: change nothing, more choices in terms of activities and layout, articles provided and make it optional to do. Eleven out of 50 students as well as one case study student, 12 out of 61 students (20%) wanted to change nothing with one student commenting, “I have nothing to change” [Student 58]. Thirty-two out of 50 students and seven of the 11 case study students, a total of 43 out of 61 (70%) wanted more choices in terms of activities and layout. Those students that wanted more choices wanted an optional activity to be included, more research questions to be included or to include more practical work that could be done relating to the research. One student said, “It is pretty good but just needs a few more choices” [Student 7]. Case study 5 suggested, “Maybe rather than specific questions have a bit more ambiguity so people can have a little free choice to investigate something that can relate back to the topic but is also of personal interest to them. An optional activity.” Case study 10 said, “I think the A and B layer should be combined so people can choose what they want to do. There should be more choices and more points.” Two of the 50 students (4%) said it was more extension type work. “Some of the A-layers went into things that don't really help us in the exam but were extension stuff. The A-layer was useful for extended students those who understood the work” [Student 15]. One student said, “In the one of the activities you should have to make a movie or video of an experiment” [Student 48]. One student and two case studies

students, three out of 61 students (5%) wanted articles to be provided and said, “If articles were provided so they could answer questions on it as it was difficult to find articles” [Student 11]. One student commented, “If some articles were provided that would make it better but you still had to do the research as well” [Case study 4] Three out of 50 students (6%) wanted to make it optional. “Make it not compulsory” [Student 5]. Another stated, “Good as an option, but I don’t think it should be compulsory” [Case study 6]. One student wanted to be able to write his or her own article rather than summarising another one. This student said, “I would change the A-layer so you had to write an article rather than summarising” [Student 12].

This section presented the findings of the types of activities found in the A-layer, why the students chose them and whether differentiated programs allowed for higher level thinking for students to be involved in. It has described the students involved in the five differentiated units who reported their findings relating to higher level thinking in each of the end of unit surveys. These were the findings from this study relating to the range of topics chosen in the A-layer—the section considered to contain the higher level thinking components, why they chose the particular topic, whether they completed it and if they thought higher level thinking skills had been employed. Further findings on the A layer were also presented. This is further discussed and processed in Chapter 5. The next section presents the findings on student aspirations.

4.8 Student aspirations

This section reports the analysis of the data used to Research question 7 that asked:

Do differentiated programs of work encourage student aspirations for their assessment level?

This section presents data about student aspirations from the Differentiated Unit Survey as well as from the Open-ended Survey (based on the interview questions) and the case studies. Both surveys and case studies reported on whether student goals changed over time with the Open-ended Survey (based on the interview questions) and case studies also reporting on whether differentiated programs inspired the students to participate more in the work.

Goals are an important factor into student motivation and tend to be categorised under two broad headings—mastery and performance goals (Cobern, 2005). Students who have mastery goals are interested in becoming proficient and understanding further whereas students who have performance goals are focussed on grades (Cobern, 2005; Pintrich, 2000).

4.8.1 Types of goals and expected achievement level

The 59 students who participated in all five differentiated units reported on what their goals were and whether they achieved to the level they expected. The findings are shown in Table 4.15.

Table 4.15 *Numbers of students indicating the types of goals for each unit and whether they achieved to the expected level*

Un it	Grade	Learn more	Complete	Understand	Other	Achieved to expected level
1	28 (47%)	03 (05%)	11 (19%)	07 (12%)	10 (17%)	33 (60%)
2	29 (49%)	03 (05%)	13 (22%)	03 (05%)	11 (19%)	37 (63%)
3	33 (60%)	03 (05%)	15 (25%)	05 (08%)	03 (05%)	49 (83%)
4	27 (46%)	04 (07%)	17 (29%)	03 (05%)	8 (13.5%)	55 (93%)
5	26 (44%)	02 (03%)	15 (25%)	05 (08%)	11 (19%)	49 (83%)
Aver age	29 (49%)	03 (05%)	14 (24%)	05 (08%)	9 (14.5%)	45 (76%)

n=59

Goals chosen by the students were based on five themes: aiming for a particular grade; students wanted to learn more; students wanted to complete the unit; students wanted to understand more; and lastly a variety of other reasons. Over the five differentiated units, an average of 49% of the students' main goal was focussed on what grade they

wanted to achieve. These numbers remained steady throughout the five units. One student said, “I mainly wanted to understand or get a grade” [Student 11]. While another stated, “I just worked out how many points I needed to get an A and just did them” [Case study 5]. One student stated, “I got higher than 60% and 60% or higher was my goal so I am very happy” [Student 48]. Five percent of students, on average over the five units, wanted to learn more about the topic. These numbers also stayed steady throughout the five units. One student stated, “I can successfully name the organs and talk about heart and lungs. Also, I can name the parts of cells and parts of blood” [Student 59]. A further 24% on average over the five units wanted to complete the unit as their goal. One student who was able to meet this goal commented, “I met my goals to the best of my ability as I completed them all” [Case study 7]. Another 8% of students on average wanted to understand the work more as their goal. Students who achieved this goal made the following comments: “I understand MRS GREN and cells now” [Student 34] and another said, “I grasped a better understanding of plants and how they work” [Student 22]. One student said, “I understand how salts were made and also made them in class to help my understanding” [Student 58].

A further 14.5% of the students on average over the five units had a variety of alternative goals and reasons for achieving them throughout the five units. These included “I was able to meet my goal because I could create items how I wanted them such as PowerPoints, posters and the webpage presentation” [Case study 9]. “I could create valuable study resources which meant I achieved my goal” [Student 15]; and “I achieved my goal by doing all of the tasks that I was familiar with, and used techniques and media that I already had background knowledge on how to use” [Case study 8].

An average of 76% of the students achieved to the levels they expected to, based on their own expectations and this generally increased as the units went on. Students that did not meet their expectations made these types of comments. One student said, “I definitely learned more but could have concentrated better” [Student 18]. Another commented, “I wanted 50 points but only got 48” [Student 27]. As time went on the numbers not achieving their goals, decreased. Reasons for not achieving included not finishing or not achieving as high a grade as they wanted. One student said, “I ran out of time due to outside commitments” [Case study 4]. In the last unit 10 students out of 59 (17%) did not achieve their goals. This was mainly due to time constraints around

examination time. One student stated, “Unfortunately, because I wasn’t able to spend as much time on it as I would have liked to because I was preparing and studying for exams, so I wasn’t able to finish a lot of my chosen activities” [Case study 1].

4.8.2 Partake in the work

Fifty students were involved in the Open-ended Survey (based on the interview questions). They reported their findings on whether the having a choice of activities made them partake more in the work and also whether their goals changed at all throughout the year. In response to whether having a choice of activities made them partake in the work, 34 out of 50 students responded favourably to this question along with nine of the 11 case study students giving a total of 42 out of 61 students (69%). Eleven out of 50 students (22%) were unsure and five out of the 50 as well as two out of the 11 case studies, giving a total of seven out of 61 students (11%) saying no.

Favourable responses to the students wanting to do the work were based on four themes: students could do what they wanted, they were more interested, they could learn more and they found it fun and enjoyable. Seven out of 50 students (14%) stated they could do what they wanted. One student said, “I was able to choose what I want to do therefore I was happy with my homework making me work harder for it” [Student 59]. Nine of the 11 case studies also stated being able to choose the activities was what made them partake more in the work. Case study 11 commented, “It was a choice and that you didn’t have to do everything. It was an interesting way of doing it. Case study 1 said, “It did because you found the ones that suited yourself.” Case study 3 stated, “You could build up from the easier tasks to the harder tasks for the different layers.” Eight of the 50 students (16%) responded they were more interested in the work. One student said, “Because it was a choice that I was more interested in than the others which made me work harder at the project [Student 49]. While another stated the following:

It made you more interested in the subject. It made you learn more about it. It made it friendlier instead of boring textbook. You could incorporate a past exam into the work. You could do a question from it. I liked being able to do a video and also bring an artistic influence over it and do a brochure. It brings you into a pattern of work style. It

became easier to do as you went through the year. Hard to start with but easier as you went through [Student 11].

Fifteen out of the 50 student (30%) stated it was more fun and enjoyable. One student stated, "It is more fun so I seemed to enjoy it. Definitely, the choice of doing different tasks and not being stuck on one track was enjoyable. It gave you more freedom" [Student 3]. Another said:

We found quite a few of the activities to be fun. We loved the poetry. It inspired us to research it a bit more to go into more depth. The different subject choices made it a lot more fun. The different subject choices made you pick something you enjoyed and were interested in as well. With subjects being compulsory, you did not enjoy them as much even if you could choose how to present them. It restricted it a bit" [Student 9].

One student stated, "Because I don't want to do something I don't like I would try more in something I enjoy" [Student 50]. "It made science more fun" [Student 13]. One student responded, "I could do what work I wanted and I could extend on what I wanted, I found this more enjoyable as I was not forced to work on anything I didn't like" [Student 22]. Four out of 50 students (8%) responded that they learned more from the work. One student responded with "It helps me get to know the topic better and helps me learn more about the topic" [Student 20]. Another stated, "In the last exam I remember some of the things from the booklet. It was active learning" [Student 15]. Students who were unsure or said no stated:

"It depends on what I am doing, if I enjoy the topic" [Student 40]. "Because I prefer more structured learning" [Student 17].

"I don't really know if it made much of a difference" [Student 27].

"I'm not really sure because I put the same amount of effort in everything I do" [Student 36].

"Not really because you had to do the tasks" [Student 42].

Two students involved in the case studies stated no with Case study 5 commenting:

I ended up choosing activities that I was not particularly interested in. As I said in some sections due to the choice of the sections, I would

just do the work as if I was given it in the normal manner. There were some aspects that I did get to enjoy more but as I said, it was disproportionate to the amount of points. The C layer was monotonous. I spent more time on the presentation, which I enjoyed more. If you had a floating-point system, then if you could put more time into the presentation, do something in a unique way, or put a different take on it that could be worth more. If taken from a different angle [Case study 5].

4.8.3 Change of goals over time

The last question in the Open-ended Survey (based on the interview questions) that 50 students participated in and the 11 case study students was to do with whether their goals changed over time. Twenty-three out of 50 students and six of the case study students, a total of 29 out of 61 students (48%) said their goals changed over the five units. Thirteen out of 50 students (26%) were unsure and 14 out of 50 students as well as five out of 11 case studies, 19 out of 61 students (31%) said they did not change. Those students that indicated yes to their goals changing gave these kinds of responses, generally around a change in grade they aspired to. One student stated, “At first my goal was to get all my work in on time, but as time passed, my goal changed to getting full marks” [Student 39]. One student commented, “I used to say I want to get over 70% and now it’s to get 100%” [Student 30]. Another student stated, “I wanted to achieve higher. To start with I wanted a B then when I found I could get higher I aimed for an A” [Student 6]. One student said, “Originally my goal was just to get through the subject. Now I want to pass” [Student 3]. While another responded, “At first I tried to get over 70% of the marks but over time I started to aim for over 90%” [Student 41]. One student said, “They changed a bit. Not sure how they changed exactly. My goal was to get a C initially but then got higher grades so started to aim for a higher mark” [Case study 10].

Case study 5’s goals did not really change with time, as he expected and achieved an A every time. He always had a grade for his goal. He always chose to work alone, never in a group and the activities he chose tended to suit his learning styles. This student is now working at a high A* level (grade given to students achieving over

90%) as he is achieving close to 100%. He shows a strong interest in science as he is taking three sciences in the following year out of a possible five subjects. It is a strong possibility that he will take science as a career. He is “keeping his options open.” Two years later and he is still taking three science subjects.

Case study 7 demonstrated that differentiated programs of work encourage student aspirations for their assessment level. From what the researcher observed of this student over the five units’ Case study 7’s goals tended to be aiming for a particular grade, which she achieved as she progressed through the units. She felt they changed over time as she aimed higher. By being able to choose the activities, she was able to meet her goals and as well could use them for study notes. Having choices inspired her to partake more in the work. “I got more interested in doing it” [Case study 7].

Case study 9 demonstrated there was a relationship between differentiated programs of work and student aspirations for their assessment level. From what the researcher observed of this student over the five units’ Case study 9’s goals changed over time and this was confirmed in her interview. Her goals ranged from “a better understanding” to choosing a grade to “completing the activities to a high standard” and to “create a visual representation.” Having choices inspired her to partake in the work. Case study 9 liked that she could choose the ones she wanted to do. This was reflected in the grades she was able to achieve for the assignments and the value added to this student’s examination results of an F grade at the beginning of the course to a D grade at the end.

From what the researcher observed of this student over the five units’ Case study 10’s goals changed over time and this was confirmed in his interview where he thought, “they changed a bit.” His goals ranged from learning key points to choosing a grade to aspire to or to try something new. Case study 10 had a different goal for each unit, which apart from the first topic he constantly achieved sometimes even surpassing his own expectations and achieving higher. In the fifth unit, he was aiming for a B grade but achieved an A. He told the researcher he was thrilled to get an A.

From what the researcher observed of this student over the five units’ Case study 11’s goals changed over time and this was confirmed in his interview. “I wanted to achieve

higher”[Case study 11]. His goals ranged from completing it to choosing a grade either an A or a B. Apart from the first unit he achieved his goals. Having choices inspired him to partake in the work once he got started with it. Case study 11 liked that he could choose the ones he wanted to do and that you did not have to do everything. He liked the B-layer as he thought, “It had interesting complicated bits.” He liked making the web page. He also liked that “You know what you are going to do and what you need to do for that” [Case study 11]. He was not keen on anything that involved what he considered too much writing. He was able to achieve to higher levels in his assignment work and to have value added to this student’s examination results of an E grade at the beginning of the course to a C grade at the end.

Three out of the 50 students (6%) their goals were to do with understanding more over the five units. One commented, “My goals have changed because I have gained more knowledge” [Student 29]. Another said, “I feel as though with the range of choices I understand more and I do get higher marks so the time to change my goals was definitely in order” [Student 43]. Other responses from individuals included: “At the start of the year my goals were more general, but now they are specific and on areas that I need to work on” [Student 40], or “I could see that it was more achievable than I originally thought” [Student 7]. Another stated, “I started doing my assignments at a higher level and I started making them look better” [Student 56]. Six out of the 11 students (55%) involved in the case studies commented that their goals had changed over the five units. Four of the 11 students (36%) said they aimed higher. One student stated, “At the start I wasn’t really certain how good I would do, but at the end I was completing everything which meant I also had good quality work. I tried to do both of these, so I was aiming higher. It meant I was getting more points” [Case study 8]. One student wanted to complete the work to the best of their ability and stated, “By the last unit I wanted to complete it to the best of my ability and get A’s” [Case study 4]. The other student who said their goals changed over time was referring to the change of grade stated, “They changed a bit. Not sure how they changed exactly. My goal was to get a C initially, but then got higher grades so started to aim for a higher mark” [Case study 10].

Students who indicated they were not sure gave these types of responses. One stated, “Because I did it with my friend I feel that we were more motivated now than doing it

by ourselves. We are probably aiming higher” [Student 23]. Another one said, “It depended on the assignment” [Student 58]. The students who responded with no their goals did not change gave five broad reasons: always tried to complete the work; goals were good enough all the time; still wanted to understand, get good marks or improve as before. Two of the 50 students (4%) said they always wanted to complete their work. One student stated, “Every assignment I tried to complete the whole thing” [Student 14]. Three out of the 50 students (6%) said their goals were good enough all the time. One student commented, “I just didn't change my goals because they were good enough for me” [Student 32]. Four out of 50 students (8%) who still wanted to understand with one responding, “I still want to learn and understand the topic like I did at the beginning of the year” [Student 18]. Another said, “My goals were to learn more about the subject I was learning [Student 37]. Three out of 50 students (6%) still wanted to get good marks, with one student stating, “My goals have always been to do well in the exams and get good grades” [Student 17]. One student wanted to continue improving and said, “My goal was to improve my knowledge and I did improve my knowledge” [Student 22]. Of the students involved in the case studies, all five stated, they were aiming for the same grade so their goals did not change. One student stated, “I just worked out how many points I needed to get an A and just did them” [Case study 5]. One student said:

In all but one of the layer assignments that I did, I achieved the level that I was hoping for (which was an A grade), however, for the last assignment I was very busy studying for exams and as a result I was not able to get the grade I was hoping for [Case study 1].

This section presented the data from the Differentiated Unit Survey on the types of goals and whether students achieved to the expected level. Data was also presented from the Open-ended Survey (based on the interview questions) and case studies. Both surveys and case studies reported on whether their goals changed over time with the Open-ended Survey (based on the interview questions) and case studies also reporting on whether differentiated programs inspired the students to partake more in the work. This is discussed further in Chapter 5.

4.9 Results summary

This chapter has presented results and observations from a variety of data sources used to collect data for this study. These were participant observations, achievement levels, Open-ended Survey (based on the interview questions), case studies, Ideas in Science Survey–pre-test and post-test and the Differentiated Unit Survey. Table 4.16 summarises the themes presented in this chapter relating to the research questions based on enjoyment, achievement, self-regulation, personal agency, self-efficacy, subject choices with career selection, learning styles, higher level thinking and student aspirations.

Section 4.2 of this chapter presented data relating to the motivation and attitude towards the differentiated unit determined in terms of their enjoyment of the work. Themes arose, based on the hands-on nature of the activities, the use of the computer, group work, how their learning was affected and that the activities involved researching. Students enjoyed the hands-on nature of the activities, the use of the computer, group work, how their learning was affected and that the activities involved researching, as they were fun, involved a choice, were interesting, helped with learning, and were easy and creative. The findings showed that student increasingly liked the units and that differentiated units of work lead to improvements in motivation and attitude to science. Section 4.3 described student achievement. Students' achievement data taken before and after the intervention showed that students' grades had generally improved over the five units some by as much as four grades.

Table 4.16 Summary of the themes used in this study

	Themes	Example
Enjoyment of the choice of activities	Fun	I enjoyed making the PowerPoint, the model was fun and the brochure was cool to do.
	Interesting	I enjoyed the medical part, as it was interesting and new.
	Helped with learning	I never made one before and so it was enjoyable and it helped me to remember key points.
	Easy	I liked doing the PowerPoints as they were easy to do in a quick amount of time.
Interested in the choice	Visual	I like to visually see things.
	Control	I get to choose what I want to do which makes it more flexible for me
	Enjoyable	I found that it made it science more enjoyable as we had choices we could make rather than sticking to one method.
	Liked to choose	It gives more choice. So, if there is something you are not really motivated to do there might be something else that you are.
	Suited learning styles	Being able to do experiments and project work definitely makes me interested in science, because we have choices to choose from to cater for our learning styles.
Enjoyment aspect of activities	Learned more	Because I could learn more about each subject than I usually would in a normal science class.
	Easy to pick	Over a wide range of activities, it's quite easy for me to pick what activity to do.
	Hands-on	I could put art on it and decorate it, so I enjoyed it more.
	Research	I enjoyed researching up and learning about new areas that I had not yet before known much about.
Research	Computer	I enjoyed doing the website, research, database activity and the PowerPoints.
	Group work	I like working in a group. It's fun to work together and share the load.
	Learn new things	I enjoyed researching the information and learning new things.
Activities not enjoyed	Relate to the environment	I liked researching topics that are relating to environment and us.
	Writing	I don't like activities that require a lot of writing as writing activities are not enjoyable.

	Themes	Example
Problems	Research	I like the fun ones; like making a book, but not really the research ones.
	Specific topics	I did not like learning about photosynthesis as I already knew about it.
	Hands-on	I did not like the creative and arty type of activities as I don't find them helpful.
	Time factors	I did not like the length of time it took to design the test.
	Time management	Yes. A few problems with organisation, which meant getting things in on time was difficult.
	Technical difficulties with computers	Sometimes I had to complete three within a limited time, which was hard for me because I don't always have internet available.
	Motivation	I think the main problem was staying focussed at the start of each assignment.
Personal agency	Understanding	That sometimes I had trouble understanding what was being asked of me.
	Finding and reading articles	Some of the A-layer was hard to find the information and you didn't know if the information was reliable or not or really scientific.
	Not being forced to do something	So, I don't have to waste time doing things I don't enjoy.
	More involved	You get to choose what you like to do. It involves you more.
	More control over choices	I could understand more by putting the information into a presentation form that suits my style of learning.
	More enjoyable	Definitely, the choice of doing different tasks and not being stuck on one track was enjoyable.
	Remember work better	In the last exam, by being able to choose what I did meant I remembered some of the things from the booklet.
Self-efficacy	Activities could be extended	I like having a choice, so I can extend on the subject I would like to, also it becomes more enjoyable. Showed my skill when doing the mini projects and improved my learning skill.
	Goals achieved	I achieved my goal by doing all of the tasks that I was familiar with, and used techniques and media that I already had background knowledge on how to use it.
Reasons to take science in later life	Career purposes	I would like to be a vet and I need to take these.
	Keep options open	If you do science it can have a wide range of opportunities, if you don't shut off some options.

	Themes	Example
	Enjoy the subject Interesting	I enjoy learning these subjects. I find them enjoyable and interesting. I find them interesting and want to learn about the world.
	No choice University	There was nothing else to take. I need these to take a science course in university as they are pre-requisites.
	Helped with other subjects Fun	Physics is useful for other subjects. It was fun to do science. It can have a wide range of opportunities, if you don't you shut off some options.
Enough choices	Different ways to show learning Good interesting activities Creative choices Easy to choose	There were enough choices as there were different ways to show my learning. There were lots of good interesting thing to choose from. There were lots of experiments and I prefer to make things than write. It wasn't difficult to choose the activities as there were plenty of them.
Changes to the program	A-layer Structure of the layers More specific types of activities More choices at times	It would be better if articles were provided for the A layer, so you could answer questions on it as it was difficult to find articles. If you could do more from different sections rather than having to do so many points from each section that would be better. I would have more experiments, because they are fun and help to learn in different ways. I found that the selection in some cases there was something and in others it lacked stuff that I would choose to do.
Reasons for choosing research activities	Real issues Knew something about it Group decided Environmental issues interesting Learn more about something unknown	It is an interesting topic happening now in the world. I chose to look at global warming as I knew a little bit about it and it is topical. I could also work on it as a group and we could all have an input on it. I also liked the activity on global warming as I was interested in learning more about it. PowerPoints are a great way to learn creatively and I had previously watched a documentary on spider silk which I knew nothing about.

	Themes	Example
Higher level thinking reasons	Related to medicine	I enjoyed the medical part, as it was interesting and new. It made me think of future careers.
	Forced to think	It made me think of things I would not have thought of.
	Remembered more	Writing my opinion on the topic made me think more about it, as I had to think about how I felt towards it which, made me remember.
Types of goals	Consider others point of view	Writing your opinion of the topic made you think about it as it meant discussions could be had and you could hear other's opinions.
	Grades	I just worked out how many points I needed to get an A and just did them.
	Learn more	I can successfully name the organs and talk about heart and lungs.
	Complete	I met my goals to the best of my ability as I completed them all.
	Understand	I grasped a better understanding of plants and how they work.
Wanting to do the work	Other	I could create valuable study resources which meant I achieved my goal.
	Could do what they wanted	I was able to choose what I want to do therefore I was happy with my homework making me work harder for it.
	More interested	It was a choice and that you didn't have to do everything. It was an interesting way of doing it.
	Learn more	It made you learn more about it.
Changes to goals	Fun and enjoyable	It is more fun, so I seemed to enjoy it.
	Aimed higher	I wanted to achieve higher. To start with I wanted a B then when I found I could get higher I aimed for an A.
	Understanding more	I feel as though with the range of choices I understand more, and I do get higher marks so the time to change my goals was definitely in order.
No change to goals	Always tried to complete	Every assignment I tried to complete the whole thing.
	Goals good enough	I just didn't change my goals because they were good enough for me.
	Still wanted to understand	I still want to learn and understand the topic like I did at the beginning of the year.
	Still wanted to get good marks	My goals have always been to do well in the exams and get good grades.
	Still wanted to improve	My goal was to improve my knowledge and I did improve my knowledge.

Section 4.4 presented the findings on student resilience describing the problems faced by the students to be time constraints, difficulty with the research, motivation problems, not knowing what to do, technical issues and organisation problems. The section went on to present the findings on how the students were generally resilient and how differentiated programs enhanced personal agency and self-efficacy. Section 4.5 presented the findings on subject selection and career. Data was presented from the 70 students who participated in the Ideas in Science Survey with both pre- and post-test data relating to taking science as a career, the types of science careers available and why they were taking the science subjects the following year. Further corroboration is shown from the findings based on the Open-ended Survey (based on the interview questions) that 50 students participated in science subject selection for the following year and onto University level and perhaps a career in science, as well as data from the 11 case studies. Section 4.6 presented the findings on choices and learning styles. The findings showed that generally, there were enough choices to cater to the students' learning styles and students generally chose activities that did relate to their learning styles tended to enjoy the activities more. The findings also showed that students were generally not keen on activities involving music as it was considered harder to do or embarrassing to sing to classmates. Section 4.7 presented the findings from the data to show that differentiated programs generally allowed students to achieve higher level thinking and further findings on the A-layer section was presented. The last section presented the findings on student aspirations for their assessment level. This included data relating to the student goals, whether they achieved them, whether the differentiated programs allowed students to partake more in the work and whether their goals changed over time. The generation of findings from these results will be discussed, in detail in the following chapter, with the aim of generating findings and conclusions from this study.

Chapter 5

Discussion

5.1 Introduction

Chapter 4 presented the results from the various surveys, interviews and observations made during the study, which provided the qualitative data for this study. The last chapter also focused on the evaluation of the five differentiated units and how the student's ideas changed over time. This chapter will discuss the decline in numbers, which gives rise to this study. Chapter 5 also discusses the remainder of the qualitative data in Section 5.3 on student enjoyment, the achievement data is analysed in 5.4, data relating to self-regulation, personal agency and self-efficacy is discussed in 5.5, subject selection and careers data is explained in Section 5.6 while the data relating to choices and learning styles is discussed in 5.7, the findings on higher level thinking is discussed in Section 5.8 and student aspirations is studied in Section 5.9. The data that is discussed in this section will systematically address each of the research questions introduced in Chapter 1 with the aim to describe the effects that a differentiated program of learning has on student career choice in the future. For each of these variables, the qualitative data has undergone coding and grouping based on the variables presented in the interview and research questions. Further to this, themes were analysed as they emerged from the qualitative data.

5.2 Decline in numbers

Disengagement from science education is an international problem (Kiemer, Gröschner, Pehmer, & Seidel, 2015; Laine, Nygren, Dirin, & Suk, 2016; Pllana, Huber, Hrdlicka, Mettouris, Veber, Ocsovszky, & Smith, 2016; Virtič, & Šorgo, 2016). In 2005 the number of students in New Zealand who were choosing a tertiary education, with the aim of taking up science careers, continued to decrease (Hipkins, & Bolstad, 2005). Since this study, further research has reported that the number of young people choosing to study science at school, is continuing to decrease, once science is no longer compulsory (Bull et al., 2010; Hipkins, Roberts, Bolstad, & Ferral, 2006). The Skills Insight Tool of the New Zealand Department of Labour predicts that there will not be enough trained people in science to meet the demands of science based occupations in New Zealand in coming years (Ministry of Business, n.d).

The researcher first became interested in studying this topic when she was presented with a difficult group of students who showed little interest in science. The group consisted of mainly boys of mixed ability with varying degrees of work ethos and girls who tried but struggled. The higher ability male students did not have a decent work ethos and showed a tendency to be lazy (as they had not had to work hard in the past). The low ability students also did not apply themselves as they found the work to be too difficult. Subjects such as science and mathematics were seen to be more challenging and less enjoyable (Wylie, & Hipkins, 2006). Science was thought to be difficult to master and only suitable for the more able students (Hassan, 2011; Kenny, 2008). Most of the girls had been assessed by the school as low to mid ability (based on school assessment results in science). Although they generally tried, they struggled with the work. Homework was often poorly done so a plan was needed to motivate the students in this science class, get them to succeed with the view of them pursuing a career later in life in the science field.

The boys were generally disruptive and much of the teacher time was spent disciplining these students and providing classroom management activities, rather than a focus on learning science content or activities. The problem in New Zealand is that students view the classroom learning environment to be slightly more negative than the OECD average (OECD, 2015). This is a problem if New Zealand wishes to retain students in science to higher levels. Hence, the evolution of this study began. Students with a knowledge of and interest in science are needed to increase the number of science professionals available in New Zealand (Hipkins, & Bolstad, 2005). Similarly, New Zealand needs a population that is literate in science to ensure informed participation in science-related debates and issues (Bull et al., 2010; Iosr, & Smith, 2014).

Numerous past studies have indicated that students have formed negative attitudes toward science by the middle years of schooling and that these negative attitudes increase throughout secondary school (Boe et al., 2011; George, 2000; Gibbs, & Poskitt, 2010; Lowe, 2004; Tytler, Osborne, Williams, Tytler, & Cripps Clark., 2008). According to educators, students still hold these poor attitudes today (Lee, Haye, Seitz, Distefano, & O'Connor, 2016). It was interesting to note that of the 37 students that

chose to take science in this study less than half did so because they enjoyed the subject. Others were taking science for future career purposes, to keep options open, because their parents made them take the subject or because there was nothing else to take. Of particular note to the researcher were those students who were taking science, because they liked the challenge of the science subjects, found them interesting and did well in them last year but were still not considering a career in science later on. Research does suggest that students have formed their attitudes to science by age fourteen due to attitudes from parents, their own experiences, views towards scientists and leisure interest in science (DeWitt et al., 2011; Lyons, & Quinn, 2010). Parent views predict children's career choice (Tytler, 2007).]. As was described earlier these students had a varying degree of work ethos and had an issue with homework. Students confirmed in the Ideas in Science Survey at the beginning of the course that they were often not keen on participating in an activity that involved writing or had to be done for homework.

This section has discussed the decline in numbers in science internationally and especially in New Zealand the problem of retaining students once the subject is no longer compulsory. The attitudes of the students involved in this study are described as this is the basis of this study to try to motivate these students to take science in later years. The next section will discuss student enjoyment to show motivation and engagement.

5.3 Student enjoyment to show motivation and engagement

This section discusses the findings from the five units and the interview data in relation to the student's enjoyment of the differentiated programs of work to show motivation and engagement to the differentiated program. Engaged students are students that put in a lot of effort, are persistent, use goal setting techniques and enjoy the challenge of the work involved (Christenson, Reschly, & Wylie, 2012). Motivation, in the present study, was considered to be "the internal drive directing behaviour towards a goal, has a timely, complex and intense influence on students' ability to complete and master their school work" (Sanchez Rivera, 2010, p. 8). Motivation can be intrinsic or extrinsic.

Students showed both intrinsic and extrinsic motivation when participating in the differentiated activities. Many students wanted to achieve a particular grade or felt pressure to get it completed by external factors. These students were motivated by extrinsic means. Extrinsic motivation results from seeking a reward or avoiding punishment (Gibbs, & Poskitt, 2010). Other students showed intrinsic motivation. Student responses included they were self-motivated, enthusiastic and interested. While others were motivated to choose topics they knew nothing about or had links to other subjects. Intrinsic motivation results from student interest and curiosity. It is self-driven and long lasting (Sanchez Rivera, 2010). Either way students were generally motivated to do the work whether they were motivated intrinsically or extrinsically. Enjoyment of the differentiated programs of work was because of being able to choose the activities they did.

Student engagement is an important aspect to ensure achievement (Fredricks, Blumenfeld, & Paris, 2004; Reyes et al., 2012). Nevertheless, engagement is often difficult to define and often used to mean motivation. Engaged students are: students that put in a lot of effort, are persistent, use goal setting techniques and enjoy the challenge of the work involved (Christenson, Reschly, & Wylie, 2012). Disengaged students are: unresponsive, off-task, distracted and will take a long time to organise themselves (Lane, & Harris, 2015).

The majority of students indicated that having a choice made them enjoy studying science. Being able to choose a Layered Curriculum approach to differentiation meant the work was fun, interesting, helped with learning, easy and were visual. They enjoyed hands-on activities, doing research, computer work and working in a group. It was interesting to note that a number of students would use their activities as study notes as they felt they were useful for examination preparation. Getting good examination results are still an important aim for students. Unfortunately, with examination pressure, students tend to view learning science as preparing for tests rather than embracing learning strategies that are deeper and meaningful that give them a higher self-efficacy (Lin, & Tsai, 2013). Experimental work was often a popular choice as well as creative activities and computer work.

The use of the computer based activities increased over the five units with students becoming more interested in producing web pages. Students found them easy to do and were visual representations of their work. Some became more interested in this type of activity when they saw others working on them and then wanted to try something new. Once they saw how easy they were to create, they became very keen to produce more web pages. Education in the 21st century has shifted from teaching face-to-face to a more technology based learning environment where more interactive student centred multimedia learning applications are being incorporated into the classroom (Li, 2016). This type of web-based learning motivates the students and provides them with a better understanding of the work as they can interact with the information and work at their own pace. According to Li (2016), this type of technology has become necessary in the classroom as students are very familiar with, and frequently use technology in their everyday lives.

This section has discussed student's enjoyment of the differentiated programs of work to show motivation and engagement to the differentiated program. By having a choice of activities, the students enjoyed the work better and were more motivated to do the work. The next section discusses student achievement.

5.4 Student achievement

This section examines the student achievement from both the interview data and the changes to grades data that was collected. Fifty students participated in the Open-ended Survey (based on the interview questions), with a further 11 extensively interviewed and all 70 students had data collected based on their achievement level at the beginning of the course and at the termination of the five differentiated units. This section discusses the findings of the interview data that sought to find out if the students understood the work better after the intervention. From there student changes to grades are examined.

The latest 2015 PISA results showed that this slipping trend in science has now stabilised with the science ranking now at 12th place ("New Zealand", 2016). The report showed socio-economic status is still a higher achievement predictor especially for Maori and Pasifika students who scored below the OECD average in science. The

problem of top performers in science has remained similar to 2012 although is still lower than before 2012 and the gap between the top and bottom 10% has increased compared with most other OECD countries.

Students involved in this study showed a range of abilities and attitudes. The Open-ended Survey (based on the interview questions) asked whether having a choice of activities helped the students understand the work better. More than half the students stated having the choice of activities meant they understood the work better. Students could choose the activities they wanted to do. Themes included they learned the work better, related to learning styles, work was reinforced in the activities they did and the work was easier to understand. As they were generally able to understand, the work better this higher achievement was reflected in the changes to grades results.

Students generally were able to achieve to higher levels than prior to the intervention—less than half were achieving a C grade or higher before the intervention and this almost doubled after the intervention. More students were achieving the higher grades than prior to the intervention. Most students improved by one or more grades with a small number who were failing with an E grade prior to the intervention improved to a C grade (between 60-69%). It was interesting to note that not only did the more-able students achieve higher grades with more students achieving an A or A*, but also the middle band achieved a larger value-added component. It was gratifying to note that even low ability and/or previously unmotivated students could achieve better results. Generally, students were able to reach higher levels achievement and could show improvement from their initial grades. A pair sample test showed the results to be significant revealing the mean grade after the intervention was greater than the mean grade before the intervention showing a significant increase in the students' results.

This section has examined the student achievement data from both the interviews and the changes to grades data that was collected. The findings of the interview data were discussed along with the data that sought to find out if the students understood the work better after the intervention. From there changes to student's grades were also addressed. The next section will discuss self-regulation, personal agency and self-efficacy.

5.5 Self-regulation, Personal Agency and Self-efficacy

This section will discuss the results of the data relating to self-regulation, personal agency and self-efficacy from the interview data. The types of problems the students faced as well as the possible solutions they used to overcome these problems are discussed along with the ways that students demonstrated personal agency and self-efficacy.

5.5.1 Self-regulation

For the purpose of this study, self-regulation was defined as the ability that students have to monitor their own behaviour, relating behaviour to both environmental effects and the way they have been brought up and self-reaction (Bandura, 1991). According to Bandura, 1991 self-efficacy plays a part in self-regulation as well as personal agency.

Prior to the intervention students work was poorly done, in general, and homework especially was often late or incomplete. Students showed an improvement in their ability to self-regulate in a number of different ways including completing set tasks, generally overcoming problems and setting goals. Over the five units, the numbers of students completing the work generally increased. Smaller numbers completed the first unit but as time went on the numbers completing the units were steadily higher.

Overall, the students did not encounter too many problems throughout the course but when they did, they were generally able to overcome them. Problems tended to include time management, difficulty finding articles for the A-layer, motivation at the beginning of the unit, technical issues and not understanding what to do. Students who were able to overcome these problems would ask for help or time manage better. Students could use goals to self-regulate and adjust how they did things or adapt what they were doing to better suit the activity. People hold beliefs about themselves and what they can do, setting goals to achieve the outcomes they desire. Students who are effective at self-regulation are able to adjust the way they do things according to the current task (Greene, Moos, & Azevedo, 2011), including persisting with tasks even if they are not enjoyed. Some students did better by choosing to do the larger activities

rather than a number of smaller ones. This meant the activities were flexible and could cater to all learning styles. Learning needs to be more personalised to cater for individual needs of the learner so they can work at their own pace (Bunting, MacIntyre, Falloon, Coslett, & Forrel, 2012).

5.5.2 Personal agency

It has been well documented that education in the 21st century should be moving away from the teacher directed learning known as education 1.0 and from education 2.0 where web 2.0 tools are used. Instead education should be a more student centred approach known as education 3.0 where learners are involved in creating collaborative knowledge and therefore taking control of their own education (Bunting, MacIntyre, Falloon, Coslett, & Forrel, 2012). According to their research, learning needs to be more personalised to cater for individual needs of the learner so they can work at their own pace. “Students should have more control over, and take more responsibility for, their own learning” (Bevins, & Price, 2016, p.19). Personal Agency refers to the extent to which individuals are involved in their own lives (Thoits, 2003, 2006). In terms of this study, personal agency means the extent to which students have control over their own learning. Personal agency is also a part of student’s ability to self-regulate. Students were able to show high personal agency throughout the course. By being in control of their learning it meant they were not wasting time on things they did not like doing. They were also able to be more involved in their learning so if they did not like one activity they could choose another. That way interests could be explored. By being able to choose, more time was spent on different activities, as they were enjoyable. Students had control over whether they worked alone or in a group and whom they would work with. Some students responded that having a choice of activities helped them to understand the work better. This self-determination was empowering for these students and is consistent with the notion that students like to have a sense of responsibility and some freedom in a science-learning environment, as evidenced in other studies (Rickards, 1998).

By being in control of their learning, the students had more confidence in what they were doing. This meant they would try new things and learn new skills. Students could also remember the work better for examination purposes. This is reflected in the achievement level results showing more students achieving higher grades.

5.5.3 Self-efficacy

Self-efficacy is a belief in oneself to have the skills to complete tasks (Cobern, 2005; Zimmerman et al., 2000). In other words being able to produce the outcomes desired by the student and at the same time avoid the undesirable ones (Bandura, 1990; Thoits, 2003, 2006). Self-efficacy is also a part of being able to self-regulate. Self-efficacy was another feature that was looked at in relation to this study and whether differentiated studies can install a sense of belief in one-self or not. In the course of this study, students were able to extend their learning, learn new skills and achieve their goals. This meant students could be more confident, achieve higher grades than they previously did and generally achieve at a higher level. Students could use techniques and media they were already familiar with and gain the confidence they needed to take risks later on when trying something new. Students commented that they were able to learn more about each subject than they usually would in a normal science class.

What was notable was that the students started expanding on the different types of activities that they normally did. As time went on students would see the work produced by others and would try it out next time. Webpages were a prime example of this happening. Students who had never tried creating a webpage would observe others making one and then realise they could make them too. By watching other students, they were motivated to try new things. This helped students remember the work better and it was something that was enjoyable to do. Bull, Gilbert, Barwick, Hipkins, and Baker, (2010) state that employers want employees who can work independently, are adaptable, can problem solve and can quickly adapt and learn new skills as well as take responsibility for all parts of a project.

Students were generally showing self-regulation, personal agency and self-efficacy. This section has discussed the results of the data relating to self-regulation, personal agency and self-efficacy from the interview data. The types of problems the students faced as well as the possible solutions they used to overcome these problems were discussed along with the ways that students demonstrated personal agency and self-efficacy.

5.6 Subject selection and career choice

This section will discuss subject selection by the students in relation to career choices that they make for their future based on data collected from the Ideas in Science Survey and the interviews. The 11 students extensively interviewed were also discussed.

One of the broad purposes for school science education is to prepare students for careers in science (Bull et al., 2010). These types of careers are often referred to as science, technology, engineering and mathematics (STEM) careers. These types of careers are what future scientists will be endeavouring to take. Less than half of the students in the study were considering a career in science at the beginning of the intervention with the majority of students able to name at least five science careers. They did tend to be the more obvious ones in the medical field or being a scientist. At the completion of the intervention a greater number of students were definitely taking a career in science. Students also had a better idea of the types of STEM careers available to them, and were able to name more of these types of careers with doctor being a popular choice both before and after the program had finished. Students having a better idea on the science careers available to them means they are better informed about their choices. One issue is that these students often do not know what STEM careers are available to them (Role Models and Work Placements, 2009). Students are not getting enough vocational guidance so they can make informed decisions on appropriate subjects (Berressem, 2011). Most had no knowledge of career options in science (Aschbacher et al., 2013).

This section has discussed subject selection by the students in relation to career choices based on data collected from the Ideas in Science Survey and the interviews. Most students considered science an important subject to take for their future career or because they simply liked the subject. These findings from the Ideas in Science Survey were confirmed by the Open-ended Survey (based on the interview questions). More students were taking science to university level and most wanted to be a doctor or an engineer.

5.7 Choices and learning styles

A learning style is not in itself an ability but rather the approach in which the student is partial to (Hatami, 2013). The students in this study had a range of preferred learning styles, as one would expect in any class situation. Approximately equal numbers of students preferred to work on their own or in-group situations. Kinaesthetic and musical learning styles were the most popular. A typical classroom includes students identified with special needs as well as those students who have not, students for whom English is not their first language, students with attention deficient disorders and students with a variety of different learning styles. (Lawrence-Brown, 2004; Nunley, 2004, 2007).

This next section discusses the findings from the Differentiated Unit Survey and the Open-ended Survey (based on the interview questions) showing data collected on the choices in the differentiated units and the learning styles of the participants. Both surveys reported on whether students thought there were enough choices. The Differentiated Unit Survey also looked at why the students chose the particular activities they did whilst the Open-ended Survey (based on the interview questions) reported on what the students would change and whether their choices reflected their learning style. The 11 students extensively interviewed are also discussed.

Based on the Differentiated Unit Survey students generally thought there were enough choices to satisfy their learning styles. This was confirmed in the Open-ended Survey (based on the interview questions) that 50 students agreed to do. Overall students enjoyed the activities for a variety of reasons. It was interesting to note that some liked to use the activities as study notes. Experiments were a popular choice both before and after the course had finished as confirmed in the Ideas in Science Survey and the Open-ended Survey (based on the interview questions). Computer activities became increasingly more popular as time went on. Students generally liked the activities and felt the choices were good with only small numbers wanting changes to be made.

Students tended to pick activities that suited their learning styles as indicated in the interviews and observed by the researcher. When students chose activities outside of their main learning styles they disliked the activity and tended to find the work boring.

One student decided to write an essay and chose this activity because he felt it would be good for study notes. He did not enjoy the activity, but was motivated to get a good grade in the examination. There is also an association between learning styles and student well-being which can also affect academic performance (Burger, & Scholz, 2014)

It was interesting to note that a number of students were strong in musical as a learning style but not all were prepared to take on the choices relating to this learning style. They tended to prefer other easier options or were embarrassed about performing in front of their peers. In the experience of the researcher students do not like to appear lacking or are fearful of being laughed at by their peers so will not always choose to take on activities that may result in this very thing happening. Case study 2 had a wide range of learning styles but never chose anything musical. When the researcher asked her why she did not choose any musical activities, she stated, “I just liked listening to music but not making music with science activities” [Case study 2]. At times, she chose written activities that were more in line with a verbal learner, which was not her preferred learning style. She thought she learned best by writing things down and learning them. Students may often have a strong learning style preference but learning styles are not fixed approaches of behaviour (Cheema, & Kitsantas, 2016; Hatami, 2013) They can be expanded and altered but the degree to which individuals can do this to suit a particular situation varies. Students need to be treated as individuals who learn in different ways (Pfeiffer, 2011).

This section discussed the findings from the Differentiated Unit Survey and the Open-ended Survey showing data collected on the choices in the differentiated units and the learning styles of the participants. The discussion included whether students thought there were enough choices, what the popular choices were and whether their choices reflected their learning style.

5.8 Higher Level Thinking

This section discusses the types of activities found in the A-layer, why the students chose them and whether differentiated programs allow for higher level thinking for students to be involved in. The A-layer in the differentiated program was designed to provide opportunities for higher level thinking. The students were able to research a

topic from the options provided and could present their findings in any way they wanted. They did however; have to offer an opinion on what they had researched, which meant they had to make a judgement about the information they gathered. In order to do this they had to think about what they had researched.

Not surprisingly, students liked the topics involving environmental issues as they related to the world they were living in (Wenzel, & Austin, 2001). Students could find lots of information and they were topics they often knew something about but wanted to know more of the real-world issues. Students need higher level thinking skills to be able to problem solve to pursue careers in STEM (Bull et al., 2010). Another popular choice was to explain a concept to a target audience such as to an ESOL student or to young children. The students had to first be able to understand what was involved before they could put the ideas into simple terms. These students felt it was a unique and fun way to show their understanding and they could be creative. Transferable skills such as critical thinking are important skills for students to have in the 21st century as they need to be able to “analyse information critically and use it creatively and effectively to provide solutions to real world problems” (Stephenson, & Sadler-Mcknight, 2016, p.72). Some children were very good at drawing and produced some fantastic work using cartoon characters to explain concepts. Other students preferred topics that they knew nothing about as it expanded their knowledge. These topics included spider silk and the medicinal uses of nuclear radiation.

Most students felt that writing their opinion made them think more about their research. They also felt challenged by the work. The researcher included a video aspect to this section as she thought it would be a novel way to show their understanding as well as being something different and interesting to do. The researcher soon discovered that the students were not keen on the video aspect, which was surprising as she thought it would be something they would enjoy doing. The students; however, whilst they did not mind the video itself, did not like having it presented to the class. They felt embarrassed by appearing in front of their peers and having to watch themselves perform. Other students felt the work was too extended for them, that it was more for better ability students.

Some students stated they did not think more doing the research as they already had an opinion formed before doing the research or as it was easy to find answers on the internet so no need to think. Another thought that there was no need to think about it, as it was something they had already thought about already.

This section discussed the types of activities found in the A-layer, why the students chose them and whether differentiated programs allowed for higher level thinking for students to be involved in. Differentiated programs were shown to generally allow the majority of students to engage in higher level thinking.

5.9 Student Aspirations

This section discusses student aspirations for the differentiated program whether they achieved their goals and whether the differentiated program made them participate more in the work. Student's goal changing over time is also discussed.

Based on the researcher's observations and confirmation from the surveys most students were interested in the final grade with a small number wanting to complete the work or improve. Some did have other goals such as creating study resources or paying more attention. As the units continued throughout the year students were generally achieving their aims apart from the last unit where time constraints due to examination pressure made it more difficult to complete the work. Goals are an important factor into student motivation (Cobern, 2005; Iverach, 2007; Marzano, 2015). Goals tend to be categorised under two broad headings – mastery and performance goals (Cobern, 2005). Students who have mastery goals are interested in becoming proficient and understanding the work further whereas students who have performance goals tend to be focussed on grades (Cobern, 2005; Pintrich, 2000).

The majority of students found differentiated programs made them partake in the work more. By being able to choose their activities, they were more likely to enjoy the work and would then complete the tasks. It was thought to be an interesting way of doing the work. Textbook work was thought to be boring by some, although one student still liked traditional textbook type work. Traditional methods often involve the use of a textbook, so not only is science perceived to be difficult by the students but science

teachers express serious concern for the textbooks being too difficult to read (Coxhead, Stevens, & Tinkle, 2010; Walker, 2011).

About one third of the students thought their goals changed over time. As they realised they could achieve higher they aimed for higher grades. For some a higher grade meant they could pass. If the goals are particularly challenging and specific, this leads to students performing to higher levels (Locke, Shaw, Saari, & Latham, 1981). Others had the same goal throughout the year, as they still wanted to get the A or learn and understand the topic as they did before.

This section discussed student aspirations for the differentiated program whether they achieved their goals and whether the differentiated program made them participate more in the work. Student's goal changing over time was also discussed.

5.10 Summary

This chapter has presented and triangulated the data set from each of the surveys and interviews. The variables included student achievement and aspirations, personal agency, self-efficacy, self-regulation and career choice to name a few.

The first research question, which related to student enjoyment leading to motivation and engagement, has been addressed using the five Differentiated Unit Survey results and the interview results. The second research question relating to student achievement was addressed using the interview data and the changes to grades information. The third research question relating to self-regulation, personal agency and self-efficacy was addressed using survey information and on-going observations over the course of the study. The fourth research question relating to subject selection and career choices was addressed using the Ideas in Science Survey, as well as both pre- and post-results. Research question five, six and seven relating to choices and learning styles, higher level thinking and student aspirations respectively, have also been addressed using these instruments. Further triangulation was done using the information from the students who were extensively interviewed. The following chapter will present the summary of the findings from this study.

Chapter 6

Conclusion

6.1 Introduction

The previous chapter focussed on discussing and formulating the findings of the multiple sources of qualitative data generated from this study. This study proposed to examine whether the development and use of a Layered Curriculum approach to differentiated learning leads to improved motivation to learn science at secondary school and self-selection of science-based careers.

The aim of this chapter is to systematically present the findings from this study as they relate to the research questions that were outlined in Chapter 1. Chapter 1 discussed students heading for science related careers or students who need science to relate to the world around them are not being effectively schooled to best adapt and prepare themselves for the changes brought about by the needs of the 21st century.

Courses of study may need to be modified to allow for higher level thinking and a greater degree of collaboration between students, and teachers and students. This study suggests that differentiated programs that incorporate the effective use of ICT and multiple modes of digital media use are needed. Traditional science courses tend to be textbook based and do not allow students to apply their knowledge and skills dynamically to new situations.

Chapter 2 involved the literature review and showed that student numbers in New Zealand for those choosing a tertiary education with the aim of taking up science careers are continuing to decrease. Further, it was shown that there might not be enough science trained people in society to meet the demands of highly skilled and innovative science based occupations.

Chapter 3 described the research design for this study employed a triangulated multi-methods approach as the research employed the collection of multiple qualitative data sources. The instruments used were various surveys, observations, case studies and interviews. Both the instruments used and the participant sample were described.

Chapter 4 presented results and observations from a variety of data sources used to collect data for this study. These were participant observations, achievement levels, Open-ended Survey (based on the interview questions), case studies, Ideas in Science Survey – pre- and post-test and the Differentiated Unit Survey. The findings were presented in accordance with the research questions relating to students’ enjoyment; achievement; self-regulation, personal agency and self-efficacy; subject selection and careers choice; choices and learning styles; higher level thinking; and student aspirations.

Chapter 5 discussed and analysed the data to generate the various findings for this study from the multiple sources of qualitative data. This allowed the researcher to triangulate the data. The findings were discussed in accordance with the research questions.

This final chapter, Chapter 6, will present the conclusions and the findings from this study. This chapter will be presented in terms of the major findings of the study (Section 6.2); the implications of the study (Section 6.3); limitations of the study (Section 6.4); future directions and further research (Section 6.5); and, finally the concluding comments (Section 6.6).

6.2 Major findings of the study

The research questions presented in this study sought to determine whether differentiated programs of work lead to an improvement in student motivation to select science as a subject in higher levels of education and whether this is a critical factor in future career choices. The findings for each of the research questions used in this study will follow.

Research Question One: Does the use of a Layered Curriculum approach to differentiated learning lead to improvements in student enjoyment of science lessons allowing students to become more interested, more engaged, and more motivated to take science? If so, why?

Motivation will be considered as “the internal drive directing behaviour towards a goal has a timely, complex and intense influence on students” ability to complete and master their schoolwork (Sanchez Rivera, 2010, p.8). The majority of students interviewed thought that having a choice of activities in science classes made science more enjoyable to them, and therefore, students were more interested in studying science. Having a hand in choosing the activities provided students with more enjoyment of the science based work and students reported that they learned the work better. By choosing what they wanted to do, they were not forced to do something they would not like. The choices may have been informed by their personal learning styles, which made classes and activities more flexible and tailored to what they individually wanted. Students had a feeling of being in control of their learning and being more involved and responsible. Students were motivated to try new things once they saw other students engaged in a particular activity even though they had no prior skills before the intervention. Students were able to learn these new skills and successfully complete a new activity.

Of the 11 students extensively observed and interviewed over the course of the study, 10 reported having a choice of activities made science more enjoyable. The students could be: creative; work individually, or in groups; work with the computer, or choose any other activity that they wanted. By being able to choose activities students were more motivated to put effort into the work to achieve what they wanted. So, students were not confined to one area and other ideas could be explored. Students would find out about topics that were new to them and had a sense of engagement.

One student who showed a low motivation in the past would email the researcher at all times of the night with his work showing a much higher motivation than before the study. Another found it difficult to get started at the start of the unit, but found this improved as the unit went on. These are all further in class anecdotal evidence of student attitudes and motivation improving. The 11th student was unsure if having a choice made science more enjoyable but despite his uncertainty, he spent a lot of time producing a board game that could be marketed and an animated PowerPoint, which he was very excited about. This showed a lot of motivation and diversity of thinking on his part.

The findings from this study for research question one are that the use of a Layered Curriculum approach to differentiation can lead to improvements in student enjoyment of science lessons allowing students to become more interested, more engaged and more motivated to take science. When a Layered Curriculum approach to differentiation are utilised, student attitude, engagement and motivation are improved.

Research Question 2: Can the use of a Layered Curriculum approach to differentiated learning lead to enhanced student achievement?

The results from this study showed that the use of a Layered Curriculum approach to differentiated leads to enhanced student achievement with the majority of students achieving higher grades than before the course started. Student results mainly improved between one and four grades across all grade areas meaning that all students across ability groups could achieve higher grades. Only a small number of students remained the same –mainly higher-grade students or went down slightly. A pair sample test showed the results to be significant revealing the mean grade after the intervention was greater than the mean grade before the intervention showing a significant increase in the students' results.

Most of the students felt that having a choice of activities helped them understand the science tasks better. For them it reinforced what they were learning in class, which meant they could have fun doing the work and therefore remember the work better. It also did not matter what they choose to do students could still learn the same things from doing different activities. The students could approach this from different angles think about it more and were therefore more engaged. The work could be adapted to suit what the students wanted to do.

Of the 11 students extensively observed and interviewed over the course of the study 10 reported that differentiated programs of work could lead to enhanced student achievement. These students were extensively interviewed and observed. During this time, they demonstrated a high commitment to their work. This was of particular interest as these students did not typically complete homework or class work in the past. Some found, very quickly, they could do well in the unit thus motivating them to continue working on their activities and enjoy science to a higher degree. The 11th

student thought that differentiated programs of work and student achievement were irrelevant. Despite this, he showed that once he had latched onto something he produced amazing work that exceeded both teacher and peer expectations.

Research Question 3: Can differentiated programs of work encourage students to self-regulate allowing students to have a sense of personal agency, as well as levels of self-efficacy?

As stated earlier, for the purpose of this study self-regulation was defined as the ability that students have to monitor their own behaviour, relating behaviour to both environmental effects and the way they have been brought up and self-reaction (Bandura, 1991). According to Bandura, 1991 self-efficacy plays a part in self-regulation as well as personal agency. People hold beliefs on themselves and what they can do, setting goals to achieve the outcomes they desire (Bandura, 2012). This in turn has an effect on career choices students aspire to (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). Students who are effective at self-regulation are able to adjust the way they do things according to the current task (Greene, & Azevedo, 2011), including persisting on tasks even if they are not enjoyed.

Prior to the intervention classwork and homework were not always completed or handed in on time on a regular basis. Students did not respond favourably to homework. As the intervention proceeded students showed an improvement in their ability to self-regulate in a number of different ways including completing set tasks, generally overcoming problems and setting goals. Over the five units, the numbers of students completing the work generally increased with an average of 82% completing the units. Smaller numbers (58%) completed the first unit but as time went on the numbers completing the units were steadily higher.

Most students felt that they had at least some problems to overcome in science. The main types of problems they faced included time management, difficulty-finding articles for the A-layer assignments, and motivation at the beginning, technical issues or not understanding what to do. On the whole, problems were overcome by asking the teacher or others for help, figuring it out for themselves, choosing some activities that took less time, organising themselves better or adapting the problem and finding

creative ways to overcome the issue. Most students showed their ability to self-regulate to varying degrees and felt they had achieved to the level they required.

Of the students extensively interviewed during the course of this research, five out of the 11 felt they did not encounter any problems. The students who had problems typically experienced computer related issues, problems getting started or time constraints. Most students managed to overcome these problems by changing the activity or persevering with what they were doing. Some ended up putting a lot of effort into their work. They all felt they had achieved to the expected level of achievement. One student even felt he had done a lot better. Certainly, the change in grades over time indicated the students were achieving well, and this enhanced their enjoyment of science.

For the purposes of this study, personal agency refers to the extent to which individuals are involved in their own lives (Thoits, 2003, 2006). In other words achieving the preferred outcome on one's own behalf (Smith et al., 2000). These beliefs help motivate students as it is not enough to have goals and the skills to achieve those goals. Students need to believe they can achieve these goals (Ford, 1992) and these goals must be active and have a value to the individual for a student to be motivated to succeed. Personal agency is also a part of a student's ability to self-regulate.

Comments made by the students during the research and observations of the researcher during the time of the course did indeed show that students demonstrated that differentiated programs enable students to have high personal agency. Students felt more involved in their learning because they could choose what they wanted to do so they were not forced to have to do something that was seen as less relevant or productive. There was a level of student responsibility and freedom in the classes and this empowered students, with a sense of personal ownership of some tasks. They could explore their interests and had more freedom to select relevant tasks, which practically applied science in the classroom. Students were not confined to one area making the work more relevant for them. These meant students were enjoying what they were doing and learning more from it. Students reported that learning became much more active than it had been in the past.

The 11 students who were interviewed also demonstrated high levels of personal agency as they were in control of their learning more than they had been in other classes. They could choose what they wanted to do whether it involved computer work and creating webpages or discussing new options for research. Students could be as creative as they wanted to be and produced notes in their own words that could assist with study. Work could be done in groups or completed at home individually. They could select activities that interested them or do the ones that suited them the best. This they reported enabled them to learn and remember science activities and content better.

Self-efficacy is a belief in oneself having the skills to complete tasks (Zimmerman et al., 2000). In other words being able to produce the outcomes desired by the student and at the same time avoid the undesirable ones (Bandura, 1990, 2012; Thoits, 2003, 2006). Students with higher levels of self-efficacy show higher performance and are better achievers (Bandura, 1990). By participating in the differentiated programs, students were able to have a more positive sense of belief in themselves. They could not only do the work but could extend it from the standard responses that they may have given in the past. This made students feel more confident in what they were doing in science. Students reported that they could achieve higher levels in class and were generally doing better than they had before. Self-efficacy is also a part of being able to self-regulate.

Students who were extensively interviewed also showed that differentiated programs effect self-efficacy. All 11 of them showed a greater belief in themselves and that they were aiming higher with many of them achieving an A in the course work. They stated they had done a good job, generally completing all tasks well and by achieving their goals. Students also reported that they had improved their background knowledge of science and had a greater interest in science as a positive area of study. These students were able to provide desirable outcomes for themselves and achieve to the level desired by the school and their parents also.

The findings for this study from research question three showed that differentiated programs of work enabled students to be able to self-regulate, have a sense of personal agency, as well as have higher levels of self-efficacy.

Research Question 4: Does the use of differentiated programs of work encourage students to select science in subsequent years leading to a career in science and to what extent do students know about science related careers?

Of the students taking science subjects, 37 students had chosen at least one science subject at the beginning of the course. Fourteen of these students enjoyed the various science subjects and eight were taking them for career purposes. Thirty-four students indicated they would take science as a career. After the five interventions, 65 students indicated that they intended to take at least one science in the following year and 44 indicated that they would take science as a career. Twenty-six students indicated that they were now intending to go on to university and take science subjects. Six students were not considering taking science to university level and a further eighteen were unsure. Students could also name a wider range of science related careers than listed prior to the study, so student awareness of the available choices in science careers was improved.

Of the 11 students interviewed three students of mixed ability indicated at the beginning of the course that they would take science as a career. Five stated they would not and the other three were unsure. These eight students were a mixture of abilities with two of them being very high in ability. By the end of the course, eight students of very mixed ability were going to take science as a career with the majority of them taking two to three sciences the following year. The other three were not pursuing a career in science though one of these students did state they might become a geneticist. Despite this, two were continuing with one science subject. Two years later and nine of these students were still at the school. All nine were currently taking at least one science subject.

Ability levels did not seem to come into their decision to take science further as students with a range of abilities were opting into the sciences. Students were interested in the work as they enjoyed what they were doing more as indicated in the first research question.

This section has reported the findings from this study and shown that the use of differentiated programs of work encourage students to select science in subsequent years leading to a career in science. The extent that students know about science related

careers also improved. Differentiated programs of work provided a more positive experience for students studying science and a greater ability to self-select activities that maybe more personally relevant to students. This takes a practical and constructivist perspective into the classroom.

Research Question Five: Do students perceive the choices prescribed for differentiated programs of work sufficient to match their learning styles, and do these choices reflect the types of activities the students then choose to do and what changes would they make to the activities?

The students filled in a learning styles profile based on Gardner's Multiple Intelligences to determine what type of activities would best meet the needs of the students (Gardner, 1993). This study involved producing differentiated programs of work as the basis of the layered activities which incorporated ICT and different learning styles from Nunley's (Nunley, 2004, 2007) differentiated programs of work. The differentiated programs were layered to offer higher levels of thinking and incorporated different learning styles. A point system was used as a gauge to assess how well the students had achieved in each unit and a way of keeping track of the types of activities they had chosen.

The results showed that musical, kinaesthetic, intrapersonal and interpersonal learning styles were popular learning styles. Logical, verbal and visual were the least preferred. In spite of these preferred choices, equal numbers also disliked musical and kinaesthetic as a learning style. Activities were, however, produced to cater for all the learning styles.

The majority of the students felt there were enough choices in the range of activities to suit their learning styles. Students were happy with the way the activities were set up and generally could find something they liked in every layer, describing the program as being balanced, as well as interesting, fun and exciting. Students tended to choose computer based activities or experiments but did get more adventurous with the choices as time progressed. More students started enjoying the science based research work. Time constraints were still an issue for some students for various reasons. Some thought the program was great as it was and would not make any

changes to the program. Others thought that small changes to some areas were needed. Some activities could be worth a few more points or some of the A-layer research questions needed a wider variety of topics.

Students tended to choose activities that suited their learning styles as it made them more interested in science and they felt that it was good that they could do their own way of learning. Students who chose activities outside of their learning style tended not to like the activity and found it boring. Musical as a learning style was a strength for some students, as determined by their Multiple Intelligences profile, but was not used largely to choose the activity they would do. Some students were embarrassed to perform and felt other activities were easier to do so tended not to choose this option.

Of the 11 students interviewed, all of them tended to choose activities that suited their learning style. Three of these students also had musical as one of their main learning styles but tended not to choose music as a way of representing their information. They liked listening to music, but did not want to perform in front of the class. Eight of the interviewed students felt that there were enough choices to suit their learning styles in all of the sections and that they liked them all. The other three thought there were mostly enough for them and they mostly liked all of them but felt they could be a bit repetitive at times. One of these students liked the C-layer but not so much the A or B-layers.

The small changes that students reported were needed in some areas came under five broad themes: changes to the A layer; changes to the structure of the layers; some larger activities, more of a specific type of activity; and more choices were needed. Overall students perceived the program to be very good. The findings from this study suggest that students do perceive the choices prescribed for differentiated programs of work sufficient to match their learning styles and the choices tend to generally reflect the types of activities the students then choose to do.

Research Question 6: Do various forms of differentiation allow for higher level thinking for all students, as well as engagement, and motivation and what do students perceive to be improvements to the A-layer section of the differentiated program?

In this study, students could choose from a range of research topics to investigate their chosen area and then present them in any format that they liked. Environmental issues were popular choices as they related to the world around them. Other students liked activities that involved explaining concepts to a targeted audience, as it was a fun way to show their understanding of the work. Most of the students managed to complete these activities though time constraints were an issue at times. As the units progressed a greater percentage of students were completing them.

The majority of the students felt they were thinking more about their chosen research topics and tasks. More research had to be done to grasp the topic. Thinking about the research was reported by students to cause them to learn more or remember the work better. The majority of students also liked doing the research, as they liked researching new things and found they were being extended, as well as extending themselves.

Students made comments on what they thought regarding the research section, which fell into four main groups. Some felt it was good as it was, others thought more topics were needed, a few thought that articles could be provided as at times it was hard to find what they were looking for and a small number thought it should be optional to do.

The 11 students who were extensively interviewed all thought that the A-layer allowed for higher level thinking and generally found the research interesting. One student, although they found the work interesting stated it should be optional. Students generally chose to do a variety of different topics and liked finding out about new things.

The findings from this study suggest that various forms of differentiation do allow for higher level thinking for the majority of students. These students increasingly enjoyed participating in the research activities.

Research Question 7: Do differentiated programs of work encourage student aspirations for their assessment level?

Students generally stated that they achieved to the expected level or higher. Only two students indicated they achieved below their expectations. This was because of issues associated with time constraints at examination time.

Most students also said the program made them participate to a higher degree in the science work tasks. As they could choose what they wanted to do, they were more interested in what they were doing and therefore wanted to know more. They reported this as increased levels of self-motivation to do science.

Approximately one third of students thought their goal changed over time. Some aimed higher or to work more on specific areas, finding that it was more achievable than they thought. For those whose goals did not change they were aiming and achieving the various grades they wanted right from the start.

Out of the 11 students interviewed eight thought that they generally achieved to the level they desired. One student thought that he achieved to a higher level than he expected and two more said that they did not. Most of these students felt the differentiated program made them participate more in the work with only two students stating that this was not the case.

In terms of goals changing from previous classes, only five stated that goals did change with three of them changing their goals to include a higher level of attainment. The other six stated their goals did not change as the majority were aiming for the grade they achieved. The findings from this study suggest that generally differentiated programs of work encourage student aspirations for their assessment level.

6.3 Implications from the study

School programs are not meeting the needs of students in New Zealand schools (Bull et al., 2010). Students heading for science related careers or students who need science to relate to the world around them are not being schooled for the changes brought about by the needs of the 21st century. Student engagement has also shown to decrease in the middle years at school from Year seven to 10 both in New Zealand and internationally. Reasons for this may include greater levels of subject choice, images of science

careers, difficulty of science subjects and student engagement with science. Students demonstrate engagement on a continuum from compliance to extrinsic and then onto intrinsic motivation. For students to succeed they report that they need experiences at school to be more interesting and relevant. This includes their sense of personal agency, self-efficacy, involvement, effort and levels of concentration. Goal orientation is also important. The report produced by Gibbs and Poskitt (2010) suggested there was a significant gap in New Zealand literature relating to student engagement of the middle Years seven to 10. This study contributes to this gap, and attempts to provide information to improve the literature in this area.

What is unique about this study is that it has been able to demonstrate that differentiated programs are associated with changes in levels of student self-efficacy in science classes and that they allow for personal agency to develop in students as a result of self-regulation. Students engaged in this study reported they were able to improve the belief that they have in themselves to complete science based tasks. This enabled them to achieve higher levels in science classes.

Self-efficacy is something that can be learned as it is based on observation and personal experience (Akomolafe et al., 2013). Students reported that they very quickly learned that they could achieve higher results and could remember the work better in differentiated classes, when compared to previous classes that did not provide differentiated activities. This may have started as extrinsic motivation but for some of the students it quickly turned into intrinsic motivation. Students became more interested and curious about their work. For other students the grade was still important to them as goals but generally, they were aiming for a higher grade than previously achieved in earlier units.

Students were also able to have a greater choice and input into their learning as they could choose activities that they wanted to do. This was a motivator in itself, as students were not forced to do something they were not keen to do and gave them control over their learning.

Other research using the *Questionnaire on Teacher Interaction* (QTI) has shown that when student responsibility and freedom are exhibited more frequently in teacher-

student interactions, students tend to enjoy their class subjects and their teachers to a greater degree (Rickards, 1998). These beliefs help motivate students to having goals, but this may not be enough. The students must believe they can achieve their goals and perceive value and relevance in them. Students in this study were able to demonstrate self-regulation as they could succeed regardless of earlier less positive experiences that they may have had.

Student results from this study conclude that students need to be able to participate in higher levels of thinking. The A-layer section was designed to teach students to think critically. Several questions are posed so students can analyse a real-world issue. These issues do not have a clear solution so the research the student find can support more than one answer. Students research the topic to find out current information and then form an opinion on what they have found out. These are issues that can be debated and students must take a stand on the issue.

Students also need to be able to develop greater competence with technology. This will enable them to navigate around the web and effectively deal with the enormous amounts of information available in meaningful ways. Students need to be able to make sense of what they already have access to and use effectively, rather than be swamped with the huge volumes of data presented to them via the internet.

Collaboration skills are also important and have been identified by educators as one of the 21st century skills necessary for students to be successful with (Mathews, 2012). Differentiated programs enable students to participate in research that allows for higher levels of thinking for most students. Students found the work interesting even though some stated the work extended them beyond what the curriculum required, or what they had considered possible for them to complete prior to the differentiated learning interventions.

Schools need to prepare students for tertiary education so school programs need to be more individualised and cater for the divergent and idiosyncratic needs of each student in a science class. Differentiated programs are ideally set up with this in mind. As demonstrated in this study, activities cater for all learning styles and all abilities, and apply a constructivist view of self-selection based on the student recognising their own

prior learning. Students can be as creative as they wish select activities that involve experimental design or be computer based.

Schools that show innovation in integrating ICT into their teaching practices show an improvement in the teaching and learning process (Sangrà, & González-Sanmamed, 2010). Students engaged in this study were able to gain skills in web design and other computer based programs, which they reported as useful to have in any field. This study is noteworthy and unique in that it focuses on a Layered Curriculum approach to differentiated learning, which science teachers can implement, into their own teaching practices to motivate students to continue with science to higher levels. New Zealand, and indeed the world, needs a population that is able to actively participate and innovate in science-related endeavours. As well, science education should provide students with a knowledge of and interest in science to increase the number of students selecting science as they progress in their education pathways. This in turn may increase the science-based professionals available to society in the longer term.

Students in this study have demonstrated that their level of attainment generally increased when they engaged with differentiated science based activities, some quite dramatically, which led to more students opting to take science in the following year. They reported that their longer-term aim at this point was to pursue a science related career later on.

6.4 Limitations of the study

The overarching aim of this study was to provide new information about whether differentiated programs of work motivate students in New Zealand with the aim of producing students that will be interested in science as a career. Although the study has achieved this goal, there are a number of limiting factors in this study. These limitations will now be discussed.

The qualitative data involved 70 students with 50 of these students involved in Open-ended Surveys and 11 of these students extensively interviewed. A larger sample would have provided more data but was not feasible given the design of the research. The advantage of using the smaller sample included a richer data collection as the

researcher could be immersed in with the students. Multiple data collection could be done involving surveys, observations over the 12-month period and interviews.

The study was also limited in that the study was conducted in a single school at a lower secondary level offering the Cambridge curriculum. It is reasonable to suggest that the results of this study may vary with older students or students from a State Government school. Further insights may be gained by involving older students or students from a State school and would likely provide further insights to understanding how a Layered Curriculum approach to differentiated learning effects student motivation to pursue a career in science.

The study is also limited by the teacher as the researcher. Teachers as researchers “can interrupt the traditional views about the relationships of knowledge and practice and the roles of teachers in educational change blurring the boundaries between teachers and researchers” (Cochran-Smith, & Lytle, 1999, p.22).

The scope of this study also showed some limitations as not all variables could be focused on. These included ethnicity, age and socio-economic status. Practical limitations did not allow all of these variables to be considered. This does however provide directions for future research. These limitations will be discussed further in the next section.

6.5 Future Directions and Further Research

The findings of this unique study lead on to future directions for research into the ways students can be motivated. This study has shown students who show intrinsic motivation are more engaged and value their learning. These students are more likely to demonstrate deeper thinking.

The data collection for this study was conducted over 12 months and investigated motivation into science education, amongst other factors. The initial findings of this study can be built on to address the limitations discussed in the previous section.

A small sample size was used in this study. Future studies could involve using a larger sample size from a variety of different types of schools, including government state schools, single sex schools, schools with lower decile ratings or charter schools. Not all variables could be incorporated into the study. Future studies could address differences such as age, ethnicity or socio-economic groups to bring further insights into the research on a layered approach to differentiation.

Further research could be carried out into other core subject areas such as mathematics, English and social studies to investigate whether differentiation programs of work motivate students in these areas also. Subjects such as commerce, languages and technology could also be considered as the patterns of interaction and content may differ and provide valuable differences in the learning environment to investigate. It is hoped that this study is used as a model for future research into these possible areas.

6.6 Concluding Comments

This thesis provides the first study of the effects of a Layered Curriculum approach for differentiation in secondary teaching activities and students' motivation to pursue a career in a science related field in a lower secondary New Zealand school.

This study has identified the following:

1. The use of a Layered Curriculum approach to differentiated learning leads to improvements in student enjoyment of science lessons allowing students to become more interested, more engaged and more motivated to take science. This is due to students being able to choose the activities they partake in making them more interested in science.
2. The use of a Layered Curriculum approach to differentiated learning leads to enhanced student achievement. A pair sample test showed the p-value as less than 0.05 showing there is a statistically significant difference between the mean grades before and after the intervention.
3. Differentiated programs of work encourage students to self-regulate allowing students to have a sense of personal agency, as well as levels of self-efficacy.

4. The use of differentiated programs of work encourage students to select science in subsequent years leading to a career in science and enable students to know more about science related careers.
5. Students perceive the choices prescribed for differentiated programs of work sufficient to match their learning styles and these choices tended to reflect the types of activities the students then choose to do. Students were able to suggest small changes to the program as students generally liked the program as a whole.
6. Various forms of differentiation allow for higher level thinking for the majority of students, as well as engagement and motivation. The A-layer section was designed to teach students to think critically. Several questions are posed so students can analyse a real-world issue. These issues do not have a clear solution so the research the student find can support more than one answer. Students research the topic to find out current information and then form an opinion on what they have found out. These are issues that can be debated and students must take a stand on the issue. Students found this a difficult process to do initially, but improved by the last unit so the majority of students were managing this process and thinking critically about what they had written. Students perceive improvements to the A-layer section of the differentiated program to include, change nothing, more choices in terms of activities and layout, articles provided and make it optional to do.
7. Differentiated programs of work encourage student aspirations for their assessment level.

As a result, this study has provided research findings from the middle school science level as there was a significant gap identified in New Zealand and in the literature relating to student engagement of middle Years seven to 10. The results from this study have implications for science teachers in that the study focused on a Layered Curriculum approach to differentiated learning, which science teachers can implement, into their own teaching practices to motivate students to continue with science to higher levels.

Findings suggest that teaching programs need to be more individualised and cater for the unique needs of all students. Courses also need to be modified to allow for greater

levels of higher level thinking. A Layered Curriculum approach facilitates and enables both of these factors.

Science education involves preparing students for careers in science. Students with a knowledge of and interest in science are needed to increase the number of science professionals available, as well as be able to participate in discussions of science related issues.

If educators adopt differentiated programs into their schools, and cater for the needs of individual students, then New Zealand should be able to retain the interest and motivation of students studying science to higher levels of education. This would serve to increase the size of the science educated population with the intent of pursuing study and perhaps a career based in the sciences and related careers.

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Appendix: A Sample of a differentiated unit

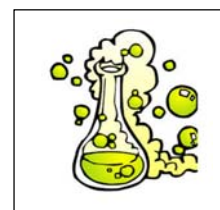
Name: _____

Final due date: _____ (4 weeks +homework)

Periodic Table & Bonding

Objectives:

- Classify substances as ionic, metallic or covalent
- write ionic formula
- Dot/cross diagrams for ionic and covalent substances



C-layer activities – basic skills

Students need to earn a minimum of 80 points to pass this assessment with a maximum of 130 points. You can choose any activities from the A, B or C-layer to earn the points but at least 10 points must be chosen from the A-layer and activities with ** are compulsory.

These can be used as part of your study notes if you choose.

You may work individually or in pairs in any of the sections. Bonus points may be earned in any section for additional effort in any activity beyond the expectation and/or by presenting your work to the class.

These can be used as part of your study notes if you choose.

You may work individually or in pairs in any of the sections. Bonus points may be earned in any section for additional effort in any activity beyond the expectation and/or by presenting your work to the class.

C-layer activities – basic skills

Activity number	Possible points	Points earned	Assignment description	Objectives Met
1**	15		<p><u>Choose one of the following. Your presentation must include-how to recognise the different types with examples, structure of each type and the properties that relate to the structure</u></p> <p>a) <u>Science through writing:</u> Produce a PowerPoint presentation on the different types of bonding – metallic, ionic and covalent. Include how to recognise different types with 10 examples of each –no less than 10 slides. Include pictures, video clips relating to the topic. Email a copy to Mrs. Waddel at the following address: Sandie.Waddel@pinchurst.school.nz</p> <p>b) Produce a video on chemical bonding (use your imagination). Ideas include: a game show, newscast, commercial or advertisement, a TV show about <i>the bonding Family</i> or, something you come up with. Present the video to Mrs. Waddel. Video needs to be at least 3 minutes long and include an explanation of 5 of the vocab words from chapter 3</p> <p>c) Design AND/or SING a song about chemical bonds. This could be based on Nelly and Justin Timberlake's song "Work it." Or another song of choice. You must teach the definitions by rewriting the lyrics and whatever else you want to include of the following words: dot/cross diagram, compound, molecule, chemical bond, ion, ionic bond, covalent bond, formula. Song can be rapped or sung and can include dance steps for extra points. Can involve up to 4 people. Can be videoed and shown to Mrs Waddel. Does not have to be shown to class (earn extra points if you do (you will need to provide the lyrics for yourself))</p> <p>d) Make up a skit about chemical bonding</p> <p>e) Draw a picture or poster, which explains ionic, covalent, or metallic bonding (must be done in colour)</p> <p>f) Draw a cartoon which involves or teaches ionic, covalent and metallic bonding</p> <p>g) Write an original story of at least one-page single space explaining ionic bonds, metallic bonds and covalent bonds. Include the properties of each.</p> <p>h) Using your choice of candy, demonstrate that you understand ionic, metallic and covalent bonding with the following substances: H₂O—covalent, Cu – metallic and KCl-ionic. Label each bond with an explanation below each bond as to why it is covalent, metallic or ionic.</p> <p>i) produce a brochure explaining bonding</p>	

C-layer activities – basic skills

2**	10		<p>Choose one of the following:</p> <p>a) Draw a cartoon involving/teaching dot/cross diagrams for ionic and covalent compounds.</p> <p>b) Use different coloured or sizes of counters, buttons or similar to model formation of compounds from dot/cross diagrams. (You will need to provide your own counters, buttons or similar to represent this) Use similar models to determine the formulas for <u>potassium chloride, magnesium bromide, and aluminium sulfide</u> – note only show outer electrons and label your model.</p> <p>c) write an essay or a children’s story book explaining how to draw dot diagrams to a year 9 student –both ionic and covalent</p> <p>d) Come up with another idea of how to present dot/diagrams. Discuss with Mrs Waddel</p>
3	10		<p>Choose one of the following (you may pick more than one of these):</p> <p>a) Record a 5-10-minute conversation about chapter 3 onto a device with your parents or friends. Include 5 of the vocab words as well as a basic and overall explanation about the main points from chapter 3. Include definitions. Be prepared to be tested on them.</p> <p>b) Design a test over chapter 3. Test must be typed and include at least 5 matching, 5 true and false questions, and 5 fill in the blank type questions. Answer sheet must also be provided.</p> <p>c) Choose 10 vocabulary words from Chapter 3 and translate these words into 3 different languages (must include Maori as one of the languages). Include what the words mean.</p> <p>d) Make vocabulary flashcards of the words in bold print in chapter 3. Learn them. Be prepared to be tested on them.</p> <p>e) Log onto Best Choice and complete 50 pts from section 3.2 on bonding</p>
4	5 per set		Summary questions from the textbook page(s)
5	5		Parent signature

Bonus points earned for presenting your work to the class or exceptional effort.



B-layer activities-application

This can be done in pairs. Present neatly.

Activity number	Possible points	Points earned	Assignment description	Objectives met
1	15		Design an experiment that relates structure to bonding in all 3 bonding types. Include at least 3 different properties to investigate. Show Mrs Waddel your results.	
2	15		Create a board game or similar that members of the class could play that would relate structure to bonding in all 3 bonding types. You will need to include at least 4 properties for each type.	
3	15		Create a web page that would teach someone to relate structure to bonding in all 3 bonding types. You will need to include at least 4 properties for each type.	
4	15		Covalent compounds are frequently gases or liquids and ionic compounds are usually solid at room temperature. Why? Research this question and then design and carry out an experiment, which demonstrates the answer to this.	
5	15		Write an essay or produce a children's book that clearly shows you understand all the material in chpt 3. You can expand on your C-layer activity if you wish.	

Bonus points earned for presenting your work
to the class or exceptional effort.

A-layer activities- higher level thinking



You must earn a minimum of 10 points from this section to complete requirements.

These may be presented in any format you like including a video, PowerPoint, debate, verbal or written report etc. Be as creative as you wish. It does not need to be written. These activities are deliberately kept open. You may work in pairs.

Optional bonus points may be earned as follows-up to 10 points for each one:

1. a good presentation to the class
2. extra effort

Research one of the activities below.

- a) answer the questions relating to the activity (**the actual articles you find need to be handed in and NOT the websites**)
And

- b) *State your opinion of the article in 6-10 sentences.*

Include statements such as did you like or dislike it or agree or disagree with what you found out? Evaluate critically the topic in the paragraph you write.

Activity number	Possible points	Points earned	Assignment description	Objectives met
1	20		What is a "Bucky ball?" What is graphene? Who first synthesized these substances? What practical applications might such Nano-sized spheres or tubes have in the future?	
2	20		Do heavy metals as well as other chemicals pose a threat to the health of humans? Can exposure to heavy metals such as lead, or radon as a radioactive chemical element, cause health problems? Is the incidence of these problems higher in one area than another? Formulate a hypothesis as to what you think is the potential health risk in your topic and do the proper research to prove whether your hypothesis is right or wrong.	
3	20		Scientists trying to find patterns among the elements, in the process to develop the periodic table, had to cope with a few problems. To start with, some of the so-called elements were actually compounds (<i>pure substance containing two or more elements</i>). Data was often incomplete and inaccurate. Furthermore, they had not realized that not all the elements had been discovered. Research the lives of at least 3 scientists who played an important role in the development of the periodic table. By analysing your information, decide which scientist played the most important role in the development of the periodic table citing reasons. Some suggested scientists to choose from Mendeleev, Meyer, Newlands, Seaborg, Dobereiner, Mosley, and Dalton.	

A-layer activities—higher level thinking

Award:

A 120-130pts

B 100-119 pts

C 80-99 pts

PARENT SIGNATURE: _____ (5 pts towards "C" layer)

NB: Students should spend 1-2 hours per week working on this assignment per week

My goal for this assignment is:

How well did you meet your goal?

Explain:

Appendix B: Differentiated Unit Survey



Tick the box to indicate gender.

Male

Female

1. What is your preferred learning style?
2. What was your goal for this unit?
3. Did you meet your goal?

Why or why not?

4. What types of presentations have you chosen in the C-Layer section?
What made you decide to choose those particular ones to do?
5. Was there enough to choose from to cater for your learning style(s)?
Give further detail.

What else would you like to see included?

6. What presentation(s) did you choose to do in the B-layer section?
What made you decide to choose that or those particular ones to do?
7. What topic did you choose to do in the A-layer section?
8. What made you decide to choose that particular one(s) to do?
9. Did you complete every task for the area you choose to do in the A-layer section?
Give further detail. What did you complete?
What didn't you complete? Why not?
Did writing your opinion make you think about the topic? Comment on this.
10. Please outline what aspects of this assignment you enjoyed?
Why did you enjoy these ones?
11. Please outline what aspects you didn't enjoy in this unit?
Why didn't you enjoy these ones?

Appendix C: Multiple Intelligences profile

Remember everyone has all the intelligence or Smarts. You can work on and strengthen an intelligence or Smart. This review is a snapshot in time—it can and will change. M.I is a tool to help ourselves—a way to learn about others and ourselves. If you ask “what” leave a “dot”. You can leave the space blank.

Tick all the things that you do:

Section 1 – Musical

- Seeing patterns
- Listening to noises and sounds
- Dancing or moving to a beat
- Playing an instrument
- Keeping a rhythm
- Making up rhymes
- I can't do other things while listening to radio or television
- Singing songs
- Listening to many kinds of music
- Remembering tunes
- TOTAL for Section 1

Section 2 – Logical

- Keeping my things neat and tidy
- Following step-by-step directions
- Solving problems
- Disorganised people annoy me
- Adding quickly in my head
- Doing logic puzzles
- Finding the answers to all of my questions before I start a project
- Planning how to spend my time
- Working on a computer spreadsheet/database
- Make sense of things
- TOTAL for Section 2

Multiple Intelligence Profile

Tick all the things that you do:

Section 3 – Interpersonal

- Learning with others
- Understanding others' points of view
- Studying in groups
- Visiting chat rooms on computers
- Helping others
- Listening to friends
- Working as part of a team
- I dislike working alone
- Being part of clubs and other out-of-school teams
- Listening to the news or talk shows
- TOTAL for Section 3

Section 4 – Kinaesthetic

- Making things with my hands
- Sitting still is hard
- Playing outdoor games and sports
- Playing team or individual sports
- Keeping fit
- Making arts and crafts
- Dancing
- Working with tools
- Being active
- Learning by doing
- TOTAL for Section 4

Multiple Intelligence Profile

Tick all the things that you do:

Section 5 – Verbal

- Reading all kinds of books
- Taking notes helps me to remember and understand
- Write letters and e-mail to friends
- Explaining my ideas to others
- Keeping a daily diary
- Doing word puzzles, crosswords and word finds
- I enjoy writing
- Playing with words
- Making rhymes
- Debating and making speeches
- TOTAL for Section 5

Section 6 – Interpersonal

- Knowing the difference between right and wrong
- I learn best when I feel strongly about the subject
- Fairness is important
- My attitude effects how I learn
- Acting according to my beliefs
- Working alone
- Understanding why I should do something before I agree to do it
- Giving 100% effort to what I believe in
- Helping others
- Working to right a wrong
- TOTAL for Section 6

Multiple Intelligence Profile

Tick all the things that you do:

Section 7 – Visual

- Imaging ideas in my mind
- Moving things around a room
- Making art
- Using sketches and designing
- Being in plays
- Using spreadsheets to make charts, graphs and tables
- Doing three dimensional puzzles
- Watching music videos
- Remembering pictures in my mind
- Reading maps
- TOTAL for Section 7

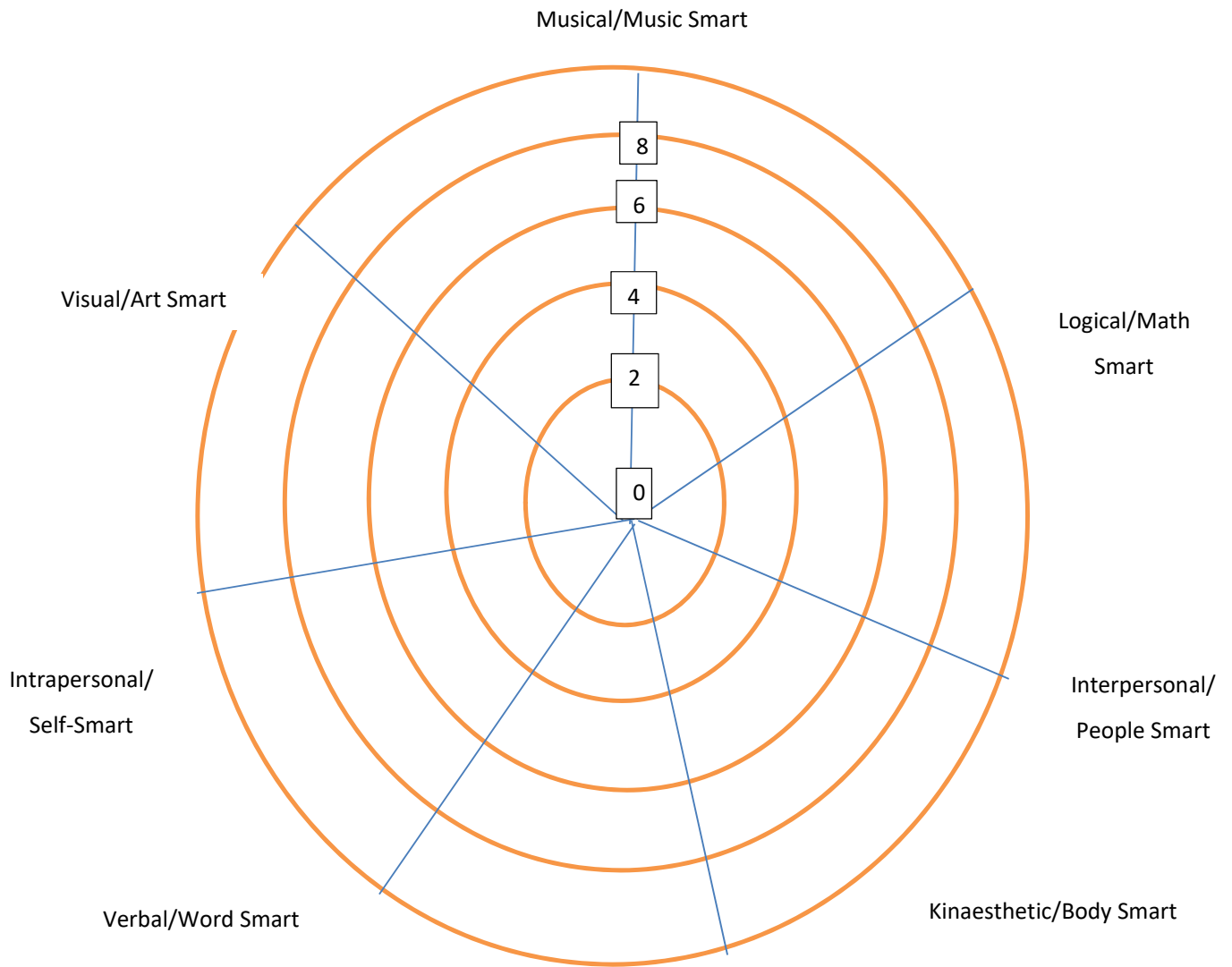
M.I. Answer Sheet

Section 1		Section 2	
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	
Total 1		Total 2	
Section 3		Section 4	
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	
Total 3		Total 4	

Section 5		Section 6	
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	
Total 5		Total 6	
Section 7			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Total 7			

Multiple Intelligences Grid

Name: _____ Date: _____



MULTIPLE INTELLIGENCES WHEEL

We all learn in different ways and have different strengths and weaknesses. This wheel shows what my favoured learning style is at present and tells me the areas I could work on.

My favoured learning style is:

I could work on:

Appendix D: Student Ideas on Science Survey

1. Tick the box to indicate gender.
Male Female
2. What do you like about science? Choose from the following. You may tick more than one box.

Projects computer work

Experiments research

Discussions other—
specify _____

3. What don't you like? Choose from the following. You may tick more than one box.

Projects computer work

Experiments research

Discussions other —
specify _____

4. What sciences are you taking this year? Please circle.
Biology Chemistry Environmental Management Physics

5. Why have you chosen to study this/these subjects?

6. Are you considering a science based career and scientific work?

Yes No

7. What career are you considering?

8. Name at least 5 careers that require studies in science.

9. Describe what would make science more interesting or enjoyable for you?

10. Any other comments?

Appendix E: The TOSRA Survey

NAME: _____

Test of Science Related Attitudes (TOSRA) (Fraser, 1981)

Directions:

1. This test contains a number of statements about science. You will be asked what you think about these statements. There are no "right" or "wrong" answers. Your opinion is what is wanted.
2. For each statement, draw a circle around the specific numeric value corresponding to how you feel about each statement. Please circle only ONE value per statement.

- 5 = Strongly Agree (SA)
- 4 = Agree (A)
- 3 = Uncertain (U)
- 2 = Disagree (D)
- 1 = Strongly Disagree (SD)

Statement	SA	A	U	D	SD
1. Money spent on science is well worth spending.	5	4	3	2	1
2. Scientists usually like to go to their laboratories when they have a day off.	5	4	3	2	1
3. I would prefer to find out why something happens by doing an experiment than be being told.	5	4	3	2	1
4. I enjoy reading about things that disagree with my previous ideas.	5	4	3	2	1
5. Science lessons are fun.	5	4	3	2	1
6. I would like to belong to a science club.	5	4	3	2	1
7. I would dislike being a scientist after I leave school.	5	4	3	2	1
8. Science is man's worst enemy.	5	4	3	2	1
9. Scientists are about as fit and healthy as other people.	5	4	3	2	1
10. Doing experiments is not as good as finding out information from teachers.	5	4	3	2	1
11. I dislike repeating experiments to check that I get the same results.	5	4	3	2	1
12. I dislike science lessons.	5	4	3	2	1
13. I get bored when watching science programs on TV at home.	5	4	3	2	1
14. When I leave school, I would like to work with people who make discoveries in science.	5	4	3	2	1

Statement	SA	A	U	D	SD
15. Public money spent on science in the last few years has been used widely.	5	4	3	2	1
16. Scientists do not have enough time to spend with their families.	5	4	3	2	1
17. I would prefer to do experiments rather than to read about them.	5	4	3	2	1
18. I am curious about the world in which we live.	5	4	3	2	1
19. School should have more science lessons each week.	5	4	3	2	1
20. I would like to be given a science book or a piece of science equipment as a present.	5	4	3	2	1
21. I would dislike a job in a science laboratory after I leave school.	5	4	3	2	1
22. Scientific discoveries are doing more harm than good.	5	4	3	2	1
23. Scientists like sports as much as other people do.	5	4	3	2	1
24. I would rather agree with other people than do an experiment to find out for myself.	5	4	3	2	1
25. Finding out about new things is unimportant.	5	4	3	2	1
26. Science lessons bore me.	5	4	3	2	1
27. I dislike reading books about science during my holidays.	5	4	3	2	1
28. Working in a science laboratory would be an interesting way to earn a living.	5	4	3	2	1
29. The government should spend more money on scientific research.	5	4	3	2	1
30. Scientists are less friendly than other people.	5	4	3	2	1
31. I would prefer to do my own experiments than to find out information from a teacher.	5	4	3	2	1
32. I like to listen to people whose opinions are different from mine.	5	4	3	2	1
33. Science is one of the most interesting school subjects.	5	4	3	2	1
34. I would like to do science experiments at home.	5	4	3	2	1
35. A career in science would be dull and boring.	5	4	3	2	1
36. Too many laboratories are being built at the expense of the rest of education.	5	4	3	2	1
37. Scientists can have a normal family life.	5	4	3	2	1
38. I would rather find out things by asking an expert than by doing an experiment.	5	4	3	2	1
39. I find it boring to hear about new ideas.	5	4	3	2	1

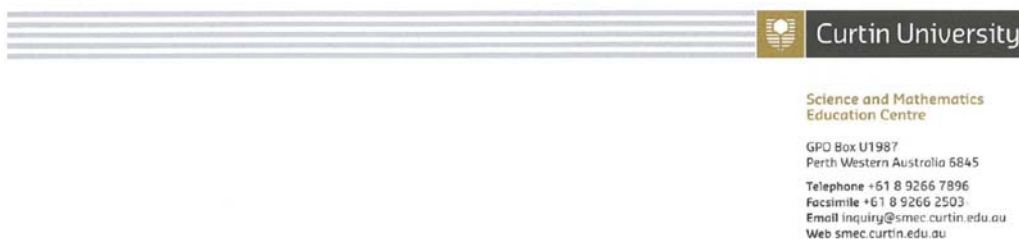
Statement	SA	A	U	D	SD
40. Science lessons are a waste of time.	5	4	3	2	1
41. Talking to my friends about science after school would be boring.	5	4	3	2	1
42. I would like to teach science when I leave school.	5	4	3	2	1
43. Science helps to make life better.	5	4	3	2	1
44. Scientists do not care about their working conditions.	5	4	3	2	1
45. I would rather solve a problem by doing an experiment than be told the answer.	5	4	3	2	1
46. In science experiments, I like to use new methods which I have not used before.	5	4	3	2	1
47. I really enjoy going to science lessons.	5	4	3	2	1
48. I would enjoy having a job in a science laboratory during my school holidays.	5	4	3	2	1
49. A job as a scientist would be boring.	5	4	3	2	1
50. This country is spending too much money on science.	5	4	3	2	1
51. Scientists are just as interested in art and music as other people are.	5	4	3	2	1
52. It is better to ask a teacher the answer than to find it out by doing experiments.	5	4	3	2	1
53. I am unwilling to change my ideas when evidence shows that the ideas are poor.	5	4	3	2	1
54. The material covered in science lessons is uninteresting.	5	4	3	2	1
55. Listening to talk about science on the radio would be boring.	5	4	3	2	1
56. A job as a scientist would be interesting.	5	4	3	2	1
57. Science can help to make the world a better place in the future.	5	4	3	2	1
58. Few scientists are happily married.	5	4	3	2	1
59. I would prefer to do an experiment on a topic than to read about it in science magazines.	5	4	3	2	1
60. In science experiments, I report unexpected results as well as expected ones.	5	4	3	2	1
61. I look forward to science lessons.	5	4	3	2	1
62. I would enjoy visiting a science museum on the weekend.	5	4	3	2	1
63. I would dislike becoming a scientist because it needs too much education.	5	4	3	2	1

Statement	SA	A	U	D	SD
64. Money used on scientific projects is wasted.	5	4	3	2	1
65. If you met a scientist, he/she would probably look like anyone else you might meet.	5	4	3	2	1
66. It is better to be told scientific facts than to find them out from experiments.	5	4	3	2	1
67. I dislike other peoples' opinions.	5	4	3	2	1
68. I would enjoy school more if there were no science lessons.	5	4	3	2	1
69. I dislike reading newspaper articles about science.	5	4	3	2	1
70. I would like to be a scientist when I leave school.	5	4	3	2	1

Appendix F: Interview questions

1. Does having a choice of activities make you more interested in studying Science? Explain your answer.
2. Does having a choice of activities help you understand the work better? Explain your answer.
3. Did you achieve to the level you expected to?
4. What problems did you encounter with learning/doing the work?
5. How did you overcome these problems?
6. Did you learn from the problems you encountered?
7. Are you planning to take any Science subjects in Year 12? If so, what are you planning to take?
8. What are you doing when you leave school?
9. If going to University or a technical college are you planning to study Science? Which ones?
10. Do you plan to take Science as a career? If so, what are you planning to do for a career?
11. Were there enough choices in the range of activities to suit your learning style?
12. What would you change about the activities?
13. How far through did you go with the A layer (the higher thinking section)? What are your thoughts on that section?
14. Did having a choice of activities inspire you to partake more in the work?
15. What did you like about the program?
16. What did you dislike about the program?
17. Did your goals change over time?
18. Would you recommend the program?
19. Any other comments?

Appendix G: Consent form



Research Study – information sheet

As part of my on-going research into what motivates students to learn Science I would like to invite Year 9 and 10 students to participate in the study. I am proposing to look at the associations between differentiation in secondary science teaching activities and student motivation to pursue a career in a science related field. Students do not need to be concerned whether, or not they are pursuing a career in Science as I am looking for all points of view.

This will involve students participating in the TOSRA survey which is a 45-minute survey and will be administered in class. The survey assesses science-related attitudes and includes students' ideas about scientists, enjoyment of science lessons, leisure interest in science, & career interest in science. Students will read a statement and then respond on the degree that they agree or disagree with the statements. The data will be kept in a locked filing cabinet for 5 years and will be viewed by myself and my supervisor.

Students at all stages will be respected both in terms of privacy and in terms of their emotional wellbeing. Students will remain anonymous by having any responses numerically coded so students can not be identified at any time throughout the course of the research or after when the findings are reported.

The aim of the research is to provide me with information that I can use to better my teaching practise. I will be producing additional resources that will aid students with their learning styles. I hope to better motivate the students and show value added. Students are under no obligation to participate and are at liberty to withdraw at any time without prejudice.

Please fill in the form provided giving permission for your child to be involved in this study.

Should you require further information my details are as follows.

Contact details of researcher:

Sandie Waddel
Science teacher at Pinehurst School
Email: Sandie.Waddel@pinehurst.school.nz

[If you wish to make a complaint on ethical grounds then the contact details of the Human Research Ethics Committee \(Secretary\) are as follows:](#)

[C/-Office of Research and Development](#)
[Curtin University of Technology](#)
[GPO Box U1987](#)
[Perth 6845](#)

[Or email hrec@curtin.edu.au](mailto:hrec@curtin.edu.au)

Thank you for your time
Sandie Waddel

Associations Between Differentiation in Secondary Science Teaching Activities And Student Motivation To Pursue A Career In A Science Related Field.

Consent Form

Name of student: _____

I give permission for my child to be involved in the learning Science research study. I understand that I can pull my child out of the research at any time without prejudice. I understand the data will be kept in a locked filing cabinet for 5 years and will be viewed by the researcher and her supervisor. I understand that my child will be respected both in terms of privacy and in terms of emotional wellbeing. I understand that my child will remain anonymous by having any responses numerically coded so he/she cannot be identified at any time throughout the course of the research or after when the findings are reported.

Signed _____
(parent/guardian)

Signed _____
(student)

Please either

1. scan the form and email to Sandie.Waddel@pinehurst.school.nz
2. return the form to Sandie Waddel in C11
