Learning Robotics Online:

Teaching a blended robotics course for secondary school students

Thesis submitted in partial fulfilment of the requirements for the Degree of

Master of Education

by

Katana Dunn

Department of Education, University of Canterbury, Christchurch

2014

Abstract

This thesis explores the use of an online robotics course, in the context of Technology Education, for senior secondary school students in an urban New Zealand (NZ) school. The reasons for using an online course are discussed through investigating the need for quality resources to assist schools in providing students with appropriate learning experiences, and knowledge to enable them to make informed choices with respect to technology careers. There is a shortage of students pursuing technology careers and that in turn influences the NZ economy (Baron & McLaren, 2006).

The purpose of the study was to examine how an online robotics course can be used for teaching robotics and engaging students in a blended environment. The author planned, implemented, monitored and reviewed an online course in robotics through an action research approach using formative evaluation methods to determine the effectiveness of the individual action research cycles. After reflection at the end of each AR cycle, the online course was modified and updated to improve student engagement. Qualitative methods were used to analyse online discussions, classroom observations and discussions, and one-to-one interviews with the participants.

Research findings identified four themes that influenced student engagement with the online robotics course: access to the online course, the students' background knowledge and skills, the students' interaction with the online course and the students' conation or internal motivation. The research findings are discussed in terms of areas that need to be addressed when using an online course to teach robotics. These areas are the course design, student considerations and course implementation. Course design, or how the course is structured, includes opportunities for students to develop their thinking skills, experiences and activities for learning, and opportunities for conversation and interaction. Course design must also accommodate student considerations. Student considerations focus on the needs of the learners and their readiness to ensure successful engagement in the online course in terms of their background knowledge and skills in electronics and Web 2.0 tools, their conation and their key competencies. Course implementation includes the factors that need to be taken into account in the execution of the online course such as reliable access to the online course, the students' interactions with the online course, and the learning culture of the school and classroom, and the role of the teacher.

The thesis justifies the rational for using an online robotics course and describes how an online robotics course can address and advance student learning outcomes, how online tools can be used for assessment purposes, the aspects of course design that are successful for teaching robotics and online learning experiences that provide positive outcomes for students. Recommendations for teaching practice in terms of school-wide programmes to develop and support students' digital literacy and key competencies, and teacher professional development in Technology Education and online robotics courses are provided. Suggestions for future research are given in terms of student conation, the development of critical thinking skills through forums and how teachers' philosophies can be aligned to Technology Education and the intent of the NZ Curriculum.

Keywords

Robotics, technology, Technology Education, online learning, blended learning, effectiveness of an online learning site, secondary school, action research, qualitative research, student engagement, student conation

Publication from this Research

Dunn, K., & Fox-Turnbull, W. (2013). *Learning Robotics Online: Teaching an Online Robotics Course for Secondary School Students.* Paper presented at the PATT27: Technology Education for the Future: A Play on Sustainability, Christchurch, New Zealand.

Acknowledgements

This has been one of the most challenging, at times frustrating but most worthwhile journeys I have been on. In many respects a roller coaster ride although at time it felt like no progress has been made. But finally I am there and I would not have been able to finish this journey without the opportunities and support various people have given me.

Firstly, I would like to thank the participant school and students, and the additional teachers, for allowing me to do the research with them. Without them I would have nothing. Secondly I would like to give my sincerest gratitude to my supervisors, Dr Wendy Fox-Turnbull and Dr Julie Mackey, for their continual guidance and support and immense patience and without whom I would not have been able to complete this. I learned so much about Technology Education, teaching and learning, and online learning, but mostly I learned a lot about myself as a teacher and a person.

Finally, a big thank you to my husband and children for their support and understanding in the many days and nights when I was stuck working on this. I know it was not always easy. Also, to all my good friends who supported and encouraged me, and those friends I may have lost because I was too busy, thank you for your friendships.

Contents

List of Tables

List of Figures

Glossary

This section clarifies some key terms that were used in this study.

Achievement Standards are New Zealand (NZ) curriculum based standards which are administered by the New Zealand Qualification Authority (NZQA). Most Technology standards can be assessed by the school's teachers (**Internal Standards**) but others called **External Standards** are assessed externally, i.e. not by the school's teachers. These assessments are marked by teachers contracted to NZQA (New Zealand Qualification Authority, n.d.). Students were able to attempt three Achievement Standards in the online robotics course (See Section 2.3 for more detail):

- AS91638 (AS3.47) – An external standard that requires students to demonstrate understanding of complex concepts in the design and construction of electronic environments
- AS91639 (AS3.48) – An internal standard that requires students to implement complex interfacing procedures in a specified electronic environment
- AS91640 (AS3.49) – An internal standard that requires students to implement complex techniques in constructing a specified complex electronic and embedded system

Constructionist vs constructivist: A constructionist learning environment is when students develop knowledge and skills through practical experience and activities. A constructivist learning environment is when students develop knowledge and skills through cognitive means.

E-learning: E-learning is learning and teaching that is facilitated by or supported through the smart use of information and communication technologies (ICT).

Educational Technologies means products like Web 2.0 tools, computers, robots and tablets used in teaching. It is how ICT is used in Education for teaching and learning.

Effectiveness in this context is the degree in which learning outcomes are achieved and the extent to which problems and issues are solved.

The **Internet vs World Wide Web** (WWW) **-** It is important to note that in this study Internet refers to the networking infrastructure (the hardware, including the computing devices like personal computer, laptop, tablet etc.) and the associated communication protocols. The school network is a private network students and staff used for school-related activities and as a gateway to the Internet. The WWW or the Web is the software that makes the Internet function. The Web includes how we access information (web pages, applications, files, folders and documents) and communicate (e-mails, chat, voice calls etc.) over the Internet. This study uses the terms Internet and the Web.

Moodle is an open source, learning management system designed to provide educators, administrators and learners with a single robust, secure and integrated system to create personalised learning environments (Moodle Pty Ltd, 2014).

NCEA: The National Certificate of Educational Achievement. The New Zealand national qualification for senior secondary students (New Zealand Qualification Authority, n.d.).

Robotics is the science of studying and creating robots. A robot is a machine that gathers information about its environment (senses it) and uses that information (thinks) to follow instructions to do work (acts).

Secondary school is the term used for schooling covering Y9 to Y13. This is normally age 13 to 19 years. **Senior Secondary School** is the term used for students from Y11 to Y13 who normally work through levels one to three of the NCEA certificate.

Technology has a complex definition and it depends on the context. De Vries (2005) uses philosophy as a foundation for exploring various meanings of technology. These are:

- Technological artefacts – The product or the outcome
- Technological knowledge – What the person needs to know to create the product (Background knowledge)
- Technological process – The methods used to create the product in an orderly flow
- Technology and the nature of humans – How human behaviour and needs influences human interaction with technology and product outcomes. This includes moral issues influencing our use of technology and the aesthetics of technology products (de Vries, 2005)

Technology Education, one of eight learning areas in the NZ Curriculum, aims for students to develop comprehensive technology literacy through the development of products and systems that addresses specific needs in society (Ministry of Education, 2007)

Chapter 1: Introduction

Employers are requesting degrees that cover science, technology, engineering and mathematics but students are not choosing these subjects (Hill, 2012). Many students view the scientific and mathematical subjects as boring and irrelevant and they don't understand why they are important (Chandra & Fisher, 2009). The reason may be because there is a shortage of teachers with the specialist skills and knowledge to teach subjects like science (Picciano & Steiner, 2008), robotics and other technology subjects, especially in rural areas (Stevens, 2011).

Students need to make informed choices about careers in technology (Baron & McLaren, 2006). If they do not get exposure to appropriate technology, how can they make valid informed choices? With the development of robotic kits, robotics has emerged in recent years as a valuable tool in education to teach students various scientific, mathematical and design concepts through the designing, building and programming of robots (Chambers, Carbonaro, & Rex, 2007).

Further to the need for more students in technology careers are the requirements for 21st Century Learning (Bellanca & Brandt, 2010). The knowledge and skills students need to succeed in their future are not currently addressed by traditional means of teaching (Snape & Fox-Turnbull, 2011). Technological development happens so fast that we do not know what is possible in the future. We do not know what knowledge and skills will be required by the students of today in their future careers (Bellanca & Brandt, 2010) and therefore, we need students to develop knowledge and skills so they can take responsibility for their own learning. This is outlined in the vision of the NZ Curriculum about the need to develop "confident, connected, actively involved and life-long learners" who can participate successfully in society (Ministry of Education, 2007, p. 8). This vision requires students to develop a set of key competencies to be successful. Students need to be able to think critically and solve problems, know how to use language, symbols and text, be able to manage themselves as well as working in groups and be able to participate and contribute effectively in groups and society. These are the foundations to enable students to become independent, self-directed learners. Gardner (2010) suggests developing these traits, in conjunction with the "Five Habits of Minds", can provide students with a foundation to develop 21st Century skills. Currently the majority of schools still cater for industrial age teaching but to address the Knowledge Age society, changes need to be made (Snape & Fox-Turnbull, 2011).

Pearlman (2010) outlined the changes needed in education to ensure 21st Century skills that should be developed. The traditional meaning of knowledge is changing and educators need to understand how it has changed and how to address it (Gilbert, 2005). In the Knowledge Age the majority of jobs will require teams of people to complete tasks. These teams are set up as project teams. Therefore, project-based learning becomes an essential element in teaching future skills and students learn to solve problems in teams (Pearlman, 2010).

Technology Education provides a valuable context for teachers to create truly 21st Century learning experiences for students to develop knowledge and skills. The aim of Technology Education is for students to develop a broad technological literacy to help them participate in society as informed citizens and give them access to technology-related careers (Ministry of Education, 2007). Robotics is a part of Technology Education because it covers the design, development and implementation of robots which are key elements of technology learning (Ministry of Education, 2007). When using robotics technology, students are able to explore new knowledge and skills through a constructionist learning approach (Ostashewski, Reid, & Moisey, 2011). The value of robotics in education is seen as a possible solution to the underlying issues we have with students not choosing mathematical and science subjects. Robotics is a valuable tool for teaching students 21st Century knowledge and skills. The use of robotic kits would allow students to learn in an active environment, constructing physical objects and experiencing concepts in a meaningful way, as demonstrated in a constructionist learning environment (Ostashewski et al., 2011). It is also not just about robots. It is about students learning more about the background and field of robotics, developing thinking skills and providing them with more choices when choosing a future career. With the right questions and challenges teachers can create a “thinking” classroom to ensure higher order thinking and problem solving skills will be developed (Lunney, Frederickson, Spark, & McDuffie, 2008).

Sir Peter Gluckman, the NZ Prime Minister's chief scientific advisor, initiated an inquiry in May 2012 into "21st Century learning and digital literacy", examining in particular how schools may need to change in the wake of the Government's $1.5 billion investment in ultrafast broadband (Pullar-Strecker, 2012). In the same Press article, Pullar-Strecker (2012) wrote “10,000 of the country's 50,000 teachers were approaching retirement and between 30 and 40 per cent of newly qualified teachers were leaving the profession within their first five years on the job. We are trying to replace an ever-increasing pool of leavers with an ever-diminishing pool of new teachers”. Using online courses to support teachers and enable students to experience modern teaching methods may help teachers with specialist subjects and expose students to 21st Century Learning.

Combining technology teaching with an online learning site will provide the students with tools to develop 21st Century knowledge and skills through self-directed learning. Online learning can support the lack of qualified and skilled teachers and provide students with access to quality resources. Chandra and Fisher (2009) reported in their study on the advantages of using a teacher-designed website in science and physics lessons. In this blended environment, teachers were able to improve student learning by innovatively including educational technologies. This is the same idea Picciano and Steiner (2008) outlined to overcome the lack of experienced teachers in science in the United States of America (USA) by using online courses. An online robotics course provides a means for technology teachers, including those with no or little robotics experience, to teach the class. Most importantly, learning robotics online can help create 21st Century self-directed, motivated learners (Ministry of Education, 2007).

The purpose of this study was to find out how an online robotics course can be used for teaching robotics and engaging students. This was achieved through:

- Exploring the use of an online environment to support the teaching of robotics
- Planning, implementing, monitoring and reviewing an online course in robotics
- Identifying best practice in online learning to improve the quality of the learning process

For this research an action research approach, using qualitative methods, has been chosen because the researcher wanted to explore how an online environment can be used to support the teaching of robotics. The main research question this study endeavours to answer is:

How can an online course be used by classroom teachers, to teach a course in robotics in the senior secondary school?

To answer the above question the following research questions will be addressed:

- *How can an online robotics course adequately address and advance student learning outcomes? How is student achievement measured?*
- *What aspects of on-line course design are successful for teaching robotics?*
- *What types of online learning experiences provide a positive outcome for students?*

In this chapter, the research was justified and aims outlined. Chapter 2 reviews literature on the philosophy of Technology Education and the place of robotics in the NZ Curriculum, blended learning environments, learning culture in the classroom and student engagement. A review of the literature about the use of course websites and online course design and ethics in online teaching have also been considered.

Chapter 3, Research Methodology and Design outlines, justifies and describes the research methodology and methods used for this study and how the data was analysed. The aim of this study was to research how an online course can be used to teach robotics to a group of Y13 students using an action research approach. In this qualitative study, considerations to ensure validity and credibility of the data and ethics are discussed. An overview of the school, participants, the role of the researcher, the data gathering process, research instruments and strategies, and the data analysis, including coding and theming, have been given.

In Chapter 4, the findings of this action research study are described in terms of access to the online course, the students' background knowledge and skills in electronics and online tools, their interaction with the online course and conation (internal motivation). Access includes the impact of the network infrastructure and hardware, access to the online environment, the frequency of students' access to the online course and laptop security. The students' background knowledge and skills in electronics and the use of online tools have been described. The interaction with the online course is described in terms of the online content, the variety of tools and simplicity or how easy it was to understand and use the online course. Conation covers a description of the school and class culture, how the students' work ethics and attitudes impacted on their engagement in the course, the influence of teacher attitude and the students' reasons for completing the course.

The research findings are discussed in Chapter 5 by addressing the structure of the course design, student considerations and course implementation and linking the analysis to the literature. The structure of the course design is discussed in terms of the elements that need to be included for successful online courses. These elements are the opportunities for students to think and reflect on their progress, learn through experiences and activities, and learn through conversation and interaction. Further to that, the students' background knowledge and skills need to be considered. Student considerations, or their readiness for online learning, are discussed in terms of their background knowledge and skills in electronics and Web 2.0 tools, their conation and their key competencies. Course implementation is discussed in terms of the reliable access to the online course, the students' interactions with the online course, and the learning culture and the teacher's influence. Finally, Chapter 6 concludes this thesis with a summary of the research, answering the research questions, and finishing with recommendations for practice and implications for future research.

Chapter 2: Literature Review

2.1 Chapter Overview

This chapter reviews the literature that informs the study. Articles and text books related to the philosophy of Technology Education, robotics in the NZ curriculum (NZC), blended learning, the role of learning culture in the classroom, and student engagement are reviewed. Attention was given to articles and text books discussing the structures of effective and appropriate online learning courses and ethics in online teaching. This review ensures the research is based on real-world experiences taking into account current accepted practices. A sample of the key literature used in this chapter is summarised in Appendix 1.

2.2 The Philosophy of Technology Education

Technology is about a purposeful intervention by design and Technology Education, one of eight learning areas in the NZC, aims for students to develop comprehensive technological literacy through the development of products and systems that address specific needs in society (Ministry of Education, 2007). In the last thirty years there has been a revolutionary shift in teachers' approaches to teaching technology. Initially, students were taught how to create products based on teachers' plans, recipes or patterns (Harwood & Compton, 2007). Now, instead of teaching students to master a specific set of skills, they are required to develop not only practical skills but also an understanding of the design process and areas to consider when designing new products, knowledge of how to use functional modelling and prototyping to evaluate fitness for purpose of products and systems, and an understanding of the impact of technology on societies and the environment (Ministry of Education, 2007). Developing this broad technological literacy allows students to be creative and to develop their potential far more than was traditionally possible; for example, the ability to transfer technological understandings into different situations. This is a significant shift in teaching pedagogy, from behaviourist-based to a complex mix of sociocultural and constructive-based practices. Many teachers trained in the traditional skills-based approach struggle with this change and extensive teacher professional development is required to support these teachers (Harwood & Compton, 2007).

Implementing this new approach in Technology Education has implications for teacher pedagogy. It requires teachers to align with a constructivist approach rather than behaviourist learning theories (Harwood & Compton, 2007). Sociocultural and constructive learning practices provide students with opportunities to participate in society as informed citizens and pursue technology-related careers (Harwood & Compton, 2007; Ministry of Education, 2007; Parkes, Zaka, & Davis, 2011). In this learning environment the role of the teachers is to provide the structure and learning programs and intervene in a timely manner when required, to ensure the students learn (Harwood & Compton, 2007).

2.3 Robotics in the NZ Curriculum

The NZC identifies three strands in the Technology learning area within which the students can develop their technological literacy. These three strands are technological practice, technological knowledge and the nature of technology (Ministry of Education, 2007). Technological practice covers planning for practice, brief development and outcome development and evaluation. Technological knowledge includes the understanding of technological modelling, products and systems. The nature of technology is about the characteristics of technology and technology outcomes (TKI, n.d.-g). Each of these strands also outlines specific achievement objectives. Student learning programs should integrate these three strands in a specific context to ensure a comprehensive approach to developing technological literacy is provided. The context can be within any technological specialist strand: construction and mechanical technologies, design and visual communication, digital technologies and processing technologies (TKI, n.d.-a). See Figure 2.1 for a visual representation of the link between the NZC and Digital Technologies Assessment Standards described in the following paragraphs. The assessments used in this study are situated within the digital technologies learning area. Also identified in the NZC are five areas of technology: structural, control, food, ICT and biotechnology. Robotics spans three of these areas: Control, ICT and structural. Control covers the feedback system of the robot to ensure automated functioning, ICT covers the programming and structural is about the structure (how it is build) of the robot to function in a specific context and environment.

At this point it is important to understand the difference between digital technologies (DGT) as a learning area and information and communication technology (ICT), as they are used in this study. When ICT is used in a classroom it means digital devices, programs and applications are used in the process of learning new knowledge and skills and engaging students. ICT is used as part of an e-learning strategy to provide accessible, relevant and high quality learning opportunities for all students creating a student-centred learning environment in all learning areas (Ministry of Education, 2006). DGT is about examining, exploring, developing and evaluating the use of digital devices, programs and applications and implementing this knowledge and skills to develop new digital devices, programs and applications that can be used in the same or different contexts. In this study, ICTs, including Web 2.0 tools and robots, were used to support the development of students' technological literacy and assist students to achieve technological learning goals.

Robotics programs can give students ownership of their learning within an active, enjoyable and

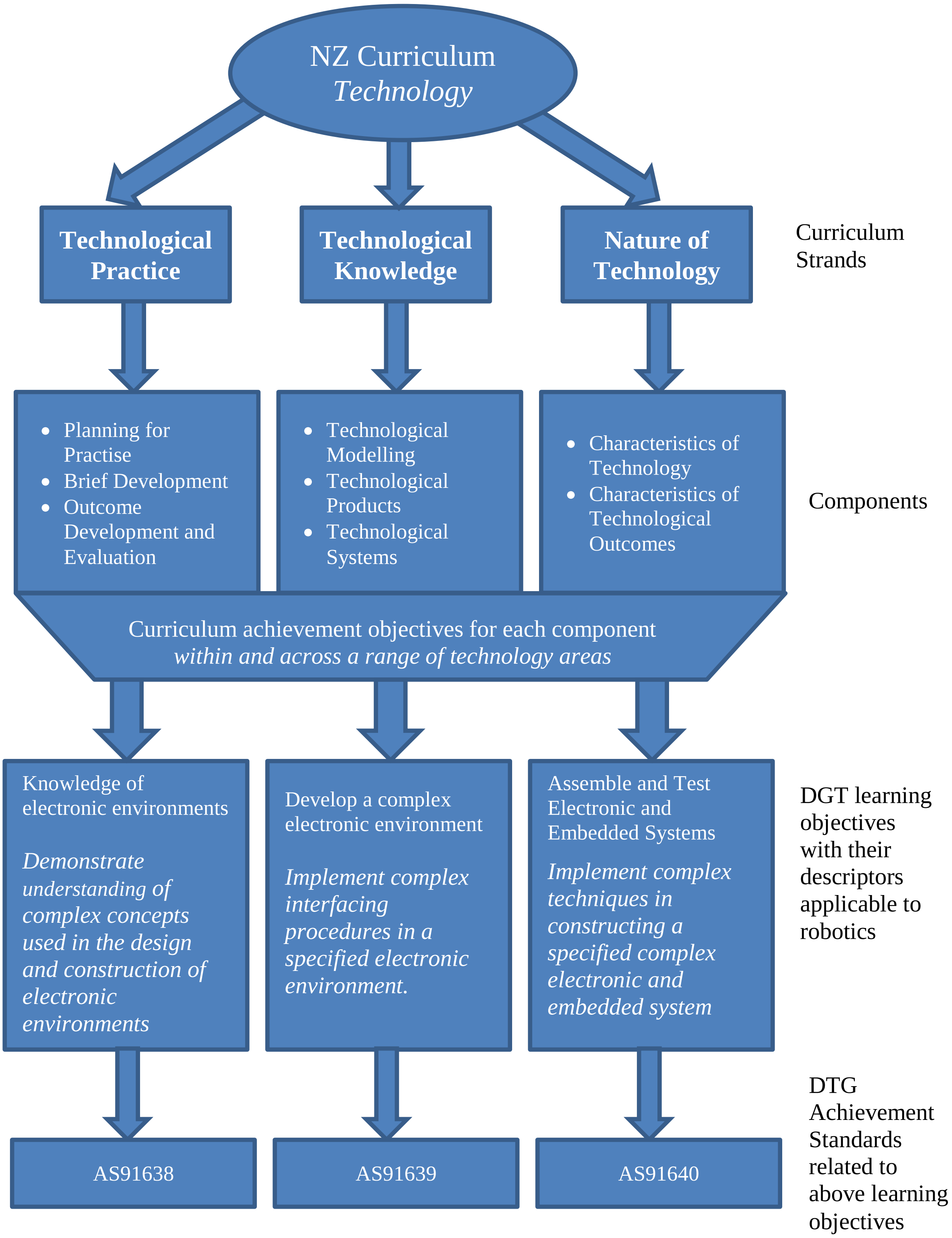


Figure 2.1 Link between NZ Curriculum and DGT Assessments

non-threatening environment (Chambers et al., 2007). Using a robotics curriculum enables the classroom teacher to produce challenging learning activities to effectively scaffold student knowledge creation. The Lego curriculum (Lego, 2011) has excellent teaching resources and the Web is also a valuable source if teachers know where to look. In this study, robots from Inex Robotics were used and supported by a comprehensive curriculum (Innovative Experiment Co. Ltd, n.d.) which was extended by the researcher. Using robotics as the vehicle will also develop students' critical thinking skills as well as their ability to solve mathematical and logical problems (Moundridou & Kalinoglou, 2008). Developing 21st Century teaching practices requires real-world experiences and robotics can be used as a vehicle to teach students the knowledge and skills required to successfully operate in the 21st Century environment. It is important for the reader to understand that although robotics can be used in a classroom as an educational learning tool to support students' understanding of a new topic in any subject, and to develop their thinking skills, in this study the students used robotic kits as a base for developing automated products and systems for the Antarctic environment.

The Robotics online course, in this study, focused on all three strands of Technology in the NZC: the nature of technology, technological practice and technological knowledge as shown in Figure 2.1. As part of the unit ignition, students explore the environment in Antarctica to ensure their technological outcome will be fit for purpose. In technological practice students critically examine the use of robotics in specific environments and construct and program a robot. They use project management practices to ensure the efficient development of their robot to a specified brief. They critically evaluate and justify their design for fitness of purpose. With technological knowledge students explore various aspects of robots and how prototyping can be used to model real world products. They develop an understanding of the technologies involved in building a robot to specification and learn to evaluate the purpose for each component that makes up a robot system. This unit was part of an Electronics subject and three digital technologies Achievement Standards have been identified around this topic: AS91638, AS91639 and AS91640. A summary of these are shown in Table 2.1. These were used because they can all fit around one theme. There are other technology standards that could have been included in the assessment of this unit; for example brief development or project management. These are shown in the Technology Matrix (TKI, 2014).

Table 2.1 Online Robotics Course: Assessments used

Achievement Standard	Learning Objective	Descriptors
AS91638 *(Ministry of Education, 2012a)*	Knowledge of electronic environments	*Demonstrate understanding of complex concepts used in the design and construction of electronic environments. (TKI, n.d.-d)* AS91638 is a discussion report where the student show or demonstrate their understanding of the complex interfaces used in a robot system. This is a theoretical report to discuss various components and part of the robot and how they interface with the microcontroller as well as how the microcontroller manages the overall functioning of the robot in a specific application.
AS91639 *(Ministry of Education, 2012c)*	Develop a complex electronic environment	*Implement complex interfacing procedures in a specified electronic environment. (TKI, n.d.-c)* AS91639 is the implementation of complex interfacing procedures in a specific electronic environment. The students are given the robot system in kit form and they have to build and construct the robot to complete specific challenges.
AS91640 *(Ministry of Education, 2012b)*	Assemble and Test Electronic and Embedded Systems	*Implement complex techniques in constructing a specified complex electronic and embedded system. (TKI, n.d.-b)* AS91639 is the implementation of complex techniques when constructing a specific complex electronic and embedded system. The students use the robot system from AS91639 but they also have to develop their own interfaces and create printed circuit boards for those.

2.4 Blended Learning Environments

Blended learning is the combination of traditional and e-learning practices in the classroom (Ministry of Education, 2006). Zaka (2012) describes this as “blended web-enhanced” teaching and learning where online courses are used to enhance face-to face teaching and learning. The traditional classroom normally uses a face-to-face delivery and teacher-centred approaches. The blended learning environment combines the best pedagogies from face-to-face and e-learning strategies to create a more active learning environment (Graham & Dziuban, 2008). Along with blended learning environments there is commonly a shift to student-centred instructions in the classroom (Watson, 2008) where teachers become the educational facilitator and the students can explore the online course and other material in their own time without restriction (Chang, 1999). The advantage of using student-centred instruction is that the students are encouraged to become active and interactive learners through social and technology interaction. Reasons to adopt a blended learning approach are therefore to improve learning effectiveness for students, increase reliable access and convenience for students, and cost effectiveness (Graham & Dziuban, 2008). Zaka (2012) also describes the advantages of blended learning in terms of increased flexibility for students, increased student engagement and motivation, increased self-management skills and the development of the students' ICT skills. Zaka (2012) also found that using a blended approach encouraged students' development of independent learning skills.

Blended learning in a classroom is a complex concept as there are no two blended learning designs that are identical. There is a continuum of possibilities, as shown in Figure 2.2, from a face-to-face classroom to a purely online course. It is the course designer's goal to create quality interactive resources to facilitate student engagement in the classroom and complement the face-to-face pedagogy through creating a community of inquiry and learning, using Web 2.0 and other online tools (Garrison & Kanuka, 2004).

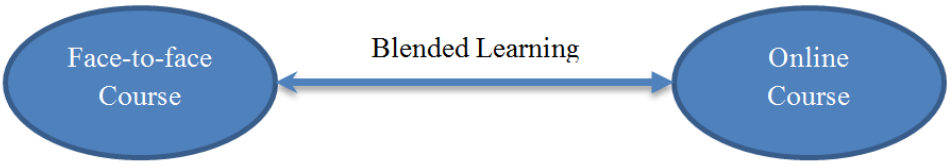


Figure 2.2 Blended Learning Continuum

2.5 Learning Culture in the Classroom

The classroom learning culture is influenced by a complex combination of parameters within the culture of the school and the wider school community. The NZ Ministry of Education created a comprehensive list of all the parameters that schools can use to determine their school culture (Ministry of Education, 2014b). These range from the school's teaching and learning character, interpersonal relationships and management structures to the resources such as equipment and buildings available to the students and staff. Many of those parameters have a direct influence in the classroom with respect to teaching approaches and student learning behaviours.

A positive learning culture will encourage in-depth learning, rigorous discussions, concentrated effort and perseverance, curiosity and a burning desire to find answers to problems and show respect to others and their property (McGee & Fraser, 2012). This culture is reinforced by the classroom teacher with the students, and is influenced by the teacher's values and philosophy of learning. For this culture to enhance learning, students need to be actively involved in making decisions, taking responsibility for their own learning, learning from their mistakes and be rewarded for their successes (McGee & Fraser, 2012).

Individual students also bring their own learning culture into a classroom through their assumptions, values and beliefs that influence who they are and their attitude towards learning (Ministry of Education, 2014a). Students' perceptions of themselves and their abilities are vital to the success of a positive learning environment (Clarke, 2005). According to Clarke (2005) it is important to address factors influencing students' motivation and self-esteem otherwise the teacher's efforts will be in vain. To support a positive learning culture the classroom should be a safe place, emotionally and physically, where students are not afraid to take risks which means there are no put-downs, sarcasm or mockery between students and between students and teacher (McGee & Fraser, 2012).

2.6 Student Engagement

Today's students are sometimes described as digital natives because they grow up with digital devices as a norm in most households (Prensky, 2001). There are many assumptions that if we put students in front of those devices, they will have no trouble engaging in the process of learning new knowledge and skills. Unfortunately, there are many reasons why students may find it challenging to learn in an online environment. Most of these reasons may have nothing to do with using digital devices but are a result of the student's internal motivation and self-management skills or the teacher's influence.

In a study by Cole (2009), it was found, half way through the course, that students had not engaged at all in a Wiki set up to support students in the subject matter. Even though the output was used for assessment most students did not publish to the Wiki while they did read information others uploaded. The main reasons stated were that students had difficulty with the technologies, problems with deadlines in other subjects, lack of confidence in posting to the Wiki where other students can read it, and some students were just not interested.

According to Shernoff, Csikszentmihalyi, Shneider, and Shernoff (2003), students' engagement requires concentrated effort, interest in the topic and a feeling of enjoyment as they complete activities. Their study of 526 high school students to determine how they spent their time and under which conditions they were engaged, found that most students experienced increased engagement if the task was challenging, the topic was relevant and their learning environment was under their control. They suggest that providing appropriate challenges and opportunities to incrementally develop complex skills that build on previously learned skills may be one of the most ideal ways to engage students. According to Stark and Woollard (2011) learning activities that are made up of a collection of smaller tasks enables the student to have enough time to reflect on the content and learning process. In their discussion paper on the use of e-portfolios in higher education, they compare student engagement with the concepts of deep learning and surface learning. Students who are engaged in deep learning are actively trying to understand ideas, looking for meaning, finding connections and creatively and innovatively building on existing knowledge and skills. On the other hand, students involved in surface learning are only interested in short-term memorising mostly for assessment purposes (Stark & Woollard, 2011). This also links to the concepts of authentic and inauthentic motivation (Jones & Issroff, 2006). With authentic motivation students are involved in robust, long-term knowledge or deep learning but with inauthentic motivation, similar to surface learning, students seem to be more interested in assessments and doing the minimum required to pass the course.

Literacy also impacts on student engagement. Literacy is the ability to read and write (Merriam-Webster, 2014). Students need to know how to read and understand text, how to communicate knowledge and ideas appropriately and they need to know the specialist vocabulary associated with each learning area (TKI, n.d.-e).

2.7 Course Websites to Support Learning

Course websites can be a valuable tool to support student learning especially because many students are not competent in using digital technologies for educational purposes (Carmichael & Farrell, 2012; Wright, 2010) and can be overwhelmed by the volume of information on the Web. Students are not as technologically competent as we believe and their technological knowledge does not automatically help them with their learning (Carmichael & Farrell, 2012). In a literature review on e-learning by Wright (2010), she also found evidence that although many students may be competent in using social networking and mobile technologies on a daily basis, they do not know how to use these technologies for educational purposes.

In creating school learning sites with comprehensive courses we can teach students the technological knowledge and skills and the key competencies all students need to be successful in society and reach their potential. These competencies are managing self, relating to others, participating and contributing, thinking and using language, symbols and text (Ministry of Education, 2007). Teaching students online skills and using other e-learning strategies “can contribute directly to the development of these key competencies” (Ministry of Education, 2006, p. 8)”. Tallent-Runnels et al. (2006), in their review of online teaching courses concluded that students prefer working at their own pace, although it requires a high degree of self-management, because they prefer the convenience and autonomy online learning provides. They also found that students, with good computer skills, who have prior experience in online learning, are more positive about online learning.

Improving students’ learning is the main criteria when developing an educational course. This shows how effective the course is in ensuring students meet learning outcomes. In recent times, online learning has been seen as the “solution” to many problems, and the direction we should be taking in new learning (Wright, 2010). However, various researchers have noted that there is not enough valuable research done into the effectiveness of online learning (Langenhorst, 2011). Jaggars and Bailey (2010) found only a small number of reasonably rigorous studies in this area despite the rapid growth in online education and the high hopes associated with it. Teacher professional development is a factor here as preparing teachers for this way of learning with help them in turn to support their students more effectively. Ostashewski et al. (2011) believe that there is a critical need for research into accessible and high quality online teacher professional development (PD) and its effectiveness to prepare teachers for 21st Century learning practices. They reported on the effectiveness of an online robotics course used for teacher PD. This course provided an opportunity for teacher participants to experience, reflect and plan the implementation of a “new” constructionist pedagogical strategy for their own instructional toolkit. The number of participants in this course is not clear but it does say that the course was provided for Atlanta educators in the USA. Their key findings that made this type of learning valuable were:

- Flexibility of access to online resources
- Being able to experience authentic learning through social networking
- Effective learning of the content.

The participants learned how to use Web 2.0 tools and how to incorporate these into their classroom teaching. The researchers used a design-based research methodology – iterative development – delivery – evaluate –redesign cycle. The advantage of teacher PD in this manner is that the teachers learned how to create their own lesson plans subsequent to the online PD course.

Although Ostashewski et al. (2011) showed that online learning is an effective way to provide teacher professional development, Carrol and Burke (2011) found many case studies that showed no advantage using online over face-to-face courses. Chang (1999) argued this was because they did not use the appropriate measuring tools. She described a web-based learning environment instrument (WEBLEI) to capture students' perceptions of web-based learning. This instrument was used to evaluate the effectiveness of online learning across four categories (scales):

- Ease of access to the Internet and how students felt in control of their own learning
- Interaction with peers and teachers including reflection, feedback and collaboration
- Response in term of how students feel about the course
- Results in terms of how well the course structure and activities supported achievement of learning goals (Appendix 2)

Chandra and Fisher (2009), in their study of a teacher-designed website used for blended learning in science and physics lessons, used the WEBLEI to measure the website's effectiveness as well as qualitative analysis of end-of-course surveys using open-ended questions. Results from the four scales showed that using the online course component was convenient and accessible, promoted self-management, and positive interactions between participants, and enabled students to work at their own pace.

Course websites can be evaluated by qualitative methods using evaluations of the participants' achievements of learning outcomes and how well they perceived they have learned. Alternatively, a quantitative approach such as WEBLEI is one way of doing this type of research. Various studies use either one or a combination of these, but to evaluate the effectiveness in terms of the students' learning and how they are developing thinking skills, a core reason to use robotics, a critical analysis of their learning development using qualitative means is required.

2.8 Online Teaching and Learning

Online teaching and learning practices requires a pedagogical shift to support 21st Century learning modes (Pearlman, 2010). These learning modes are summarised in the five key competencies students need to "live, learn, work, and contribute as active members of their communities" (Ministry of Education, 2007, p. 12). Further to this, Johnson and Anderson (2011) argues that teachers can use similar strategies in online teaching and traditional teaching by ensuring that students have targeted learning outcomes and specific resources that focus on the content. In a traditional classroom that was somewhat easier because knowledge was normally teacher-driven. It is therefore important that teachers have precise learning goals for their students and evaluate websites before the students use them or provide guidance to students when choosing appropriate websites. This is also especially true when using online resources to teach technology subjects like robotics. There are thousands of websites on the Web that may relate to a specific topic but are not always relevant as an effective teaching resource. An effective robotics online course not only needs to consider factors discussed previously such as the philosophy of Technology Education, the blended environment and the impact of the change in teacher philosophy, the impact of the learning culture and factors influencing student engagement, but also online course design where students are able to develop key competencies, the use of Web 2.0 tools to facilitate learning and the ethics that need to be considered in online teaching.

2.8.1. Course Design

To create an online course in robotics the course designer also needs to understand the philosophy of Technology Education, the learning culture and factors influencing student engagement on the course design. This means the designer needs to be aware of his/her own understanding of pedagogy, his/her approach and thinking towards learning, and knowledge about the stakeholders in the course (Seale, Boyle, Ingraham, Roberts, & McAvinia, 2006). The teacher's role in the classroom (blended or online) can be divided in three areas: course design and organisation, facilitating discussions either online or in class and direct instruction or teaching (Anderson, Liam, Garrison, & Archer, 2001). He or she also needs to organize and design the logistics of the discussions and encourage and promote students working together (Baran, Correia, & Thompson, 2011). Therefore, there must be opportunity for students to think and reflect on their progress, learn through practical experiences and activities, and learn through conversation and interaction (Dyke, Conole, Ravenscroft, & de Freitas, 2007).

Further to the above, simplicity is also a desirable feature in online course design that need to be considered because it indicates how easy it is to navigate the course site and find information (Tull, 2011). This concept, also referred to as user-friendliness, shows how easy it is for the participant students to understand and use the online course in terms of the content, the language level and navigation.

The Web opens up numerous possibilities to enable students to take control of their own learning. Therefore the pedagogy changes when using an online course site. Although it is possible to upload resources from a face-to-face teacher-directed course, to gain the benefits of an interactive media-rich environment we need to change the way we teach. When creating course websites, four key areas need to be addressed to ensure the usefulness of this teaching method. These are interactivity, modularity, collaboration and learning styles (Lynch, 2004). Within these key areas students' needs can be addressed.

Interactivity

The quality of the interaction and communication between the students and their instructor or course material influences how effective their learning is (Pachler & Daly, 2011). The instructor needs to be available regularly either face-to-face or online to guide students in their learning needs or answer questions. According to Anderson et al. (2001) facilitating online discussions is critical to maintaining student interest, motivation and engagement. In an online setting the use of interactive learning resources ensure the students take control of their learning and are able to explore course material at their own pace. The use of media-rich pages, online quizzes, simulations and hyperlinks can provide a more motivating and exciting course to explore. Hyperlinks supports social constructivist learning, or a form of discovery learning as students are able to explore online environments whilst making choices and decisions to develop their understanding of a topic (Cook, White, Sharples, Sclater, & Davis, 2006).

Using interactive online tools for assessment makes it easier for teachers to evaluate and grade students' performances. Assessment strategies like quizzes can provide valuable formative assessment opportunities (Anderson, 2009). Anderson, comparing a face-to-face class to an online class, found students' feedback provided qualitative evidence that online formative assessments help students' learning and provide increased flexibility. Students' test marks were also quantitatively analysed, and the pen-and-paper model and the online model were compared. Analysis showed that students who did the online formative quizzes tend to perform better in the summative assessments over their pen-and-paper counterpart. Anderson also identified areas of concern that teachers can analyse to modify their teaching approach. Students using online assessments showed improved student motivation, enhanced engagement with the topic and were more inclined to do revision. The Web provides a flexible environment where students could receive immediate feedback on their progress and retest themselves as many times as they like (Anderson, 2009).

Modularity

Modularity is a key factor to address in online course design and organisation. According to Anderson et al. (2001) planning and designing an online course may be more time consuming and extensive than the traditional approach. Although one reason may be course visibility, it is more likely that the teacher is forced “to think through the process, structure, evaluation and interaction components of the course” (Anderson et al., 2001, p. 5). A modular online course consists of various learning objects that are either created by the teacher or acquired from external sources. It is important to set up the course in modular units where the content explains one concept. This enables the student to master individual units before continuing. It also provides the students with options to explore only certain units based on their prior knowledge and skills.

This environment addresses diversity where different learning objects can cater for different learning styles and abilities. Using Web 2.0 tools also provides a structured environment that students in a robotics program can use to record their experiences, present what they have learned and constructively reflect on their own as well as other students' performances, effectively scaffolding their learning (Chambers et al., 2007). According to Vygotsky (1987) scaffolding is important to ensure the students are able to develop within their own zone of proximal development. With learning objects explaining single concepts in various ways, students are able to develop their own understanding of concepts. This modular approach also provides students with opportunities for self-paced learning, choosing the sequence of activities and choosing the content to access (Chou & Liu, 2005).

Collaboration

Collaboration occurs when two or more people work together to do a task. This is a key skill to develop for success in the 21st Century. Conversation forms an important part in collaboration. Fox-Turnbull (2010) outlined how conversation is important in Technology Education and how that help students to “make sense both cognitively and experientially of the world in which they live and work” (p. 26). Conversation is important in online courses as well, as shown in a study by Palmer and Holt

(2012). In 2005, when Deakin University moved a face-to-face course unit fully on-line, they initially found no improvement in student satisfaction. They modified the course to include a collaborative, compulsory online activity which improved overall student satisfaction. Palmer and Holt (2012) conducted an extensive quantitative evaluation of student responses received through surveys using a six-point scale. Results showed that including a social aspect to an online course provides for a more effective learning environment.

When creating an online learning course one of the assumptions often made is that students will not have any problems or issues using the online environment. Many students have trouble using the online environment and one of the obstacles can be online collaboration or discussions. This was found by Carmichael and Farrell (2012) who evaluated the effectiveness of an online learning site to develop students' critical thinking. They outlined a comprehensive review of the literature investigating the issues at tertiary education level with students not having the basic skills to be information literate as well as not able to be critical reviewers. Online collaboration is a skill that needs to be developed to ensure students can effectively participate in 21st Century society.

Learning Styles

Online course sites can be used to cater for students with different learning styles and needs by using multimedia, simulations and modularity. The modular approach can be used to build up units of work that can address all learning styles and needs. Diaz and Cartnal (1999) outlined five learning styles that need to be addressed to help students learn optimally. These apply to face-to-face and online courses and are:

- independent students prefer independent study and self-paced tutorials
- competitive students learn to perform better than peers and want recognition for it
- collaborative learners prefer group discussions and group projects
- avoidant learners are typically uninterested and overwhelmed by class activities
- participant learners want to be involved in all activities and work on meeting teacher expectations

Web 2.0 tools provide the course designer with opportunities to cater for this diverse range of students and also enable the course designer to facilitate the teaching and learning process, so that students are able to work anywhere, and at their own pace and development level (Lei, Krilavicius, Zhang, Wan, & Man, 2012).

2.8.2. Web 2.0 Tools

Students can use Web 2.0 tools such as Wikis for project documentation, podcasts for presentation and reporting and blogs for reflection as collaborative knowledge building tools in technology courses. These tools provide a digital environment where students can document their projects including the design, provide ways to do reflection and give constructive feedback to other students (Chandra & Chalmers, 2010). These tools can provide a framework for authentic technological practice (Fox-Turnbull, 2003) to be used in real world projects.

The use of social networking tools enhances the teaching and learning process through content sharing and idea collaboration (Lei et al., 2012). Using the Web 2.0 tools outlined above to develop critical thinking skills, which is a vital component to enable the development of new products and systems, can provide better results than the traditional classroom approach (Lunney et al., 2008). Using Web 2.0 tools to teach technology subjects also provides the opportunity to use these digital outputs as valuable resources to the wider community. Figure 2.3 shows the relationship between Technology Education, Robotics and Web 2.0 tools.

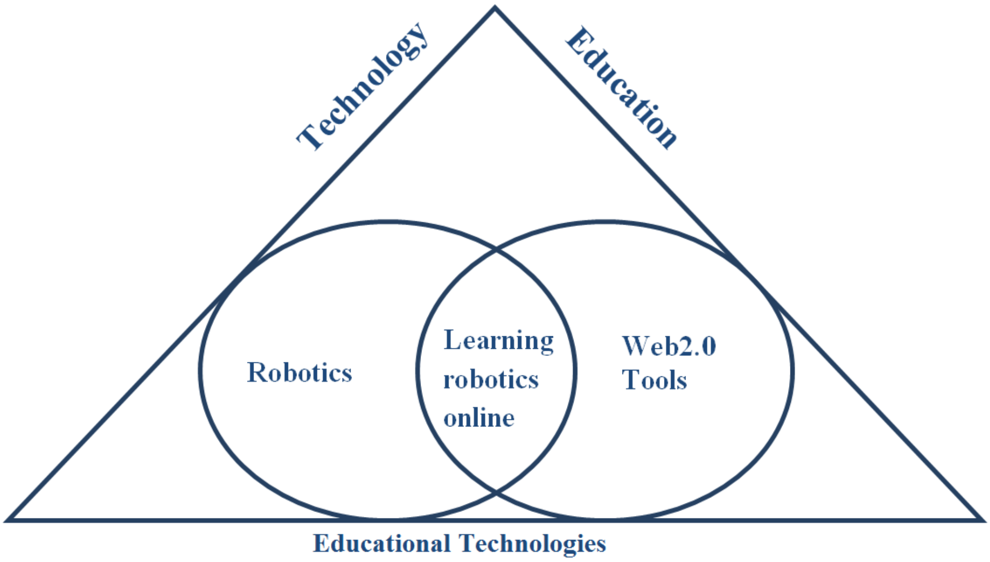


Figure 2.3 Educational Technologies within Technology Education

2.8.3. Ethics in Online Teaching

In using an online course for student learning, a number of ethical and moral issues need to be considered. Lynch (2004) discussed two major areas in online learning that influence our ethical behaviour: how we interact within our online community (virtual communication), and how we use online resources. The following areas of ethical dilemmas are discussed below (Lynch, 2004):

- **Virtual communication** and issues with language and culture. (Showing respect to all and justice)
- **Acceptable use of online resources** (Deception, safety and truthfulness)

Virtual communication

Online learning erases the traditional barriers in education by allowing access for students to a vast network of additional information (Toprak, Ozkanal, Aydin, & Kaya, 2010). This means that students can access resources and collaborate with other individuals throughout the world to improve their own learning. However; it also raises some ethical dilemmas with language and culture that may have been easier to manage in the traditional classroom.

In the NZ context the majority of online courses would be in English but many of the students who would access these courses may not be fluent in English. This creates issues with how written communication, especially without non-verbal cues may be perceived by others. In some cases, giving opposing opinions may be seen as an attack on the person rather than the ideas. Humour and silence can also have different meanings in various cultures (Lynch, 2004). Further to this is the fact that these non-English background speakers have different cultures that influence the way they communicate their understanding to others. Ethical dilemmas as a result of online communications are perceived and handled differently by different cultures (Fleischmann, Robbins, & Wallace, 2011) which may influence the value that can be added to learning by online discussions.

Lynch (2004) states that “language is an important part of cultural identity and that it is a way for us to communicate our ideas, beliefs, values and feelings” (p.173). Guidelines need to be set to help all students benefit from online discussions. A code of conduct needs to address acceptable communication and interaction values (how we treat each other) to ensure all students know what it means to show respect to each other as well as making sure that all students can benefit (improve learning) through these online discussions (Lynch, 2004).

To use virtual communication, as part of qualitative analysis of a research project, requires sensitivity to the diverse needs of the learners. It is important to build relationships with participants and to ensure that the participants build relationships between themselves. This is particularly important for Māori learners because Māori is an oral tradition and some students may find it difficult to communication online using written word (McRae, 2005) and a solution to this may be the use of more videos and podcasts.

One of the main issues with the explosion of the Web is the issue of cyber safety. Netsafe (n.d.) has extensive resources to help schools and individuals to provide a safe learning environment for all students. With the use of a structured, closed school learning site, the risks to students are minimised.

Acceptable use of online resources

Teachers want to ensure the assessments of their students are based on credible data. There are two main areas to evaluate: plagiarism and cheating on assessments (Lynch, 2004). Mutch (2005) believes that plagiarism and cheating on assessments can create ethical dilemmas to do with honesty (truthfulness), deception and emotional and psychological safety.

Assessment in technology subjects (Robotics is an example) either face-to-face or online, are mainly project-based. This means students may work in teams and the teacher (assessor) has to ensure what the individual student has actually learned and to what level. In this environment the student's performance must be assessed continuously throughout the course. This is done through regular student-teacher interactions, the student's online discussions and project reflections. Results from online quizzes should be used cautiously, as it is easy to, unintentionally, use answers from other students (Lynch, 2004). Quizzes are, however, a valuable tool to use for formative assessment.

Using an online environment, for teaching and/or educational research, exposes students to a multitude of ethical dilemmas. It is the responsibility of the school and teachers to ensure there are codes of practise to help students make ethical decisions. Teachers have an ethical responsibility to model correct behaviour and ensure that whatever teaching resources are used are appropriately referenced and can be used within copyright guidelines (TKI, n.d.-f). Allowing students to "get away with" cheating and using online resources inappropriately can influence the credibility of learning programmes.

2.9 Summary

This chapter reviewed literature from various resources to support the topic of online learning in robotics and issues that needs to be addressed. Literature explaining the philosophy of Technology Education, the place of robotics in the NZC, blended learning environments, learning culture in a classroom and student engagement has been reviewed. Literature outlining the use of course websites to support learning in the classroom have been presented. Finally, aspects influencing course design with respect to interactivity, modularity, collaboration and learning styles, the use of Web 2.0 tools and the ethics of online teaching, have been reviewed.

2.10 Research Aims

The literature review shows the need for further research into the use of online resources in the blended secondary school classroom. There is also very little research on the use of an online course to support the teaching of robotics.

The main question of this study is therefore to answer the following question:
How can an online course be used by classroom teachers, to teach a course in robotics in the senior secondary school?

To answer the above question the following research questions will be addressed:

- *How can an online robotics course adequately address and advance student learning outcomes? How is student achievement measured?*
- *What aspects of on-line course design are successful for teaching robotics?*
- *What types of online learning experiences provide a positive outcome for students?*

Chapter 3: Research Methodology and Methods

3.1 Chapter Overview

This chapter provides a description of the action research (AR) into the use of an online course to support the teaching of robotics in a blended format in a senior secondary school. The researcher adopted different roles in the participatory class over a three month period due to changing circumstances which saw the researcher move from being a participant observer, a teacher assistant and eventually taking responsibility as the classroom teacher when the regular teacher left. Over this period, data was collected and then analysed to determine how teachers and students used the online course to advance student learning outcomes. This chapter outlines, justifies and describes the research methodology and methods used for this study and how the data was analysed by first examining the theoretical perspectives and then making the philosophical links to this study.

3.1.1. Significance of topic

E-learning is one way to support students developing key competencies as outlined in the NZ Curriculum (Ministry of Education, 2007; Wright, 2010). We need to teach students to be independent learners. Therefore, using an online course in robotics has the following benefits: develop 21st Century skills; support the classroom teacher, with little or no experience in robotics; develop capacity and interest to strengthen student numbers entering engineering and technology careers.

3.2 Methodology

A qualitative methodology using a traditional AR model was used to implement and evaluate the online course for improvements, using observation and interview data, to make decision about changes for the next cycle. The aim of the study was not to prove that robotics learned online is better, but whether it can be used as an alternative or to support face-to-face teaching. This section justifies the choice of methodology by discussing the researcher’s epistemological stance, the interpretative paradigm, qualitative research and AR as a subset of applied research.

3.2.1. Epistemological Stance

Epistemology is concerned with the nature of knowledge (de Vries, 2005). Our epistemological stance is embedded in our culture, experience and how we understand our world. Design engineers transform and integrate technological knowledge from a variety of areas, including science, mathematics, social sciences and their own experiences to construct new products (de Vries, 2005). From the researcher's experience as a design engineer, technological knowledge is not only the "background" knowledge needed to develop new products, as many times in industry designers develop this knowledge while working through the design process, solving problems and extending their own cognitive abilities to ensure quality products. Therefore technological knowledge is not only the novice learning from the master but also the social epistemological approach where project teams construct new knowledge in the process of collaboration (de Vries, 2005).

This researcher's approach to learning is that the development of knowledge and skills happen through social constructivism (Fox-Turnbull & Snape, 2011). This epistemological belief supports the worldview that students learn through collaboration with others, experience situations in context and then take an action (Hoepfl, 1997). This approach was embedded into the researcher's beliefs through years of working as a design engineer as part of technical project teams in industry. Within these project teams, design engineers are able to develop technological knowledge and use appropriate processes to ensure quality outcomes.

3.2.2. Interpretative Paradigm

The interpretive paradigm is concerned with the individual and how the researcher understands the subjective world of this individual's human experiences (Cohen, Manion, & Morrison, 2011). Data from observations, interactions and interviews are used to derive meaning from the participants' experiences in a specific context. This may result in the researcher using his or her own worldview to describe actions and behaviours of those researched. There are many different ways human experiences can be described and it is not possible to provide a complete and absolute description of someone else's reasons for their actions (Scott & Morrison, 2005) because in the process of describing and re-evaluating the action after the observation or interviews were done, the context may be different. This can result in a change in the meaning of the data and how it is described. Therefore it is imperative that the researcher addresses issues influencing the trustworthiness and reliability of the data obtained (Cohen et al., 2011). In this study an interpretive paradigm using a qualitative research methodology was used to evaluate the use of an online course to teach robotics.

3.2.3. Qualitative Research

The qualitative research methodology examines human behaviours in certain real-life contexts. This means that there are no "right or wrong" for how these behaviours are described (Cohen et al., 2011). A qualitative research approach helps the researcher to describe, understand and interpret the experiences and reflections of the participants to determine their experience in a certain educational context (Bogdan & Biklen, 2007). Although qualitative research has certain limitations, for example generalisation or statistical prediction can't be made (Bogdan & Biklen, 2007), this type of research still provides a foundation for educational researchers to develop a deeper and broader understanding of human behaviours in a social environment, like a classroom (Cohen et al., 2011).

In this study, the qualitative paradigm was used to determine how an online course can be used by classroom teachers to teach a course in robotics. This evaluation was done through classroom observations, online forum interactions and interviewing the participants. This qualitative research approach was carried out in an AR framework. Reasons for the suitability of an AR methodology are outlined in the following sections, but preceded by a section on applied research and how that relates to AR before outlining the AR approach.

3.2.4. Applied Research

According to Davidson, Tolich, and Zealand (1999) applied research is all types of research with a practical, usable outcome. "It applies research to achieve some specific goal" (Davidson et al., 1999, p. 15). There are three major types of applied research:

- **Evaluation research** – Normally used to critically assess the effectiveness of a program or policy in a practical situation or how well it has achieved its goals and objectives. There are two types of evaluation research: Formative and summative evaluations. With formative evaluations there are continuous monitoring of a program to evaluate how well they work and with summative evaluations it reviews the final program outcomes (Neuman, 2005).
- **Action research (AR)** – Normally used to solve practical problems and it is about facilitating social change (Neuman, 2005). This is outlined further in the next section.
- **Social impact assessment** – A way to research how current action can have future consequences (Becker, 2001).

This study used AR, a subset of applied research, to research how an online course was used to support the teaching of robotics in a blended classroom environment.

3.2.5. Action Research

Action research (AR) is well-suited for teachers to work collaboratively in a closed environment, like a classroom, where observation of the students' learning can be done in a controlled setting. Cohen et al. (2011) explored various researcher's definitions of AR in a classroom setting and they all provide the teacher with a framework to research new teaching methods in a real-world environment. AR is doing what teachers are supposed to do, reflecting and improving their teaching. The difference between AR and classroom teaching is that AR is a systematic, planned approach, informed by theory, where observations are documented and reflected on, the plan improved and implemented again. This controlled, iterative process consisting of cycles of improvement, in a real-life scenario, makes AR ideally suited to improve teaching practice (Cohen et al., 2011), which is why it was chosen for this research. Using AR cycles, teachers are able to promote student learning using the teaching as inquiry approach to support effective pedagogy (Ministry of Education, 2007). Using teacher inquiry, teachers can find issues that are important to address, decide on strategies that can be used to address those issues and reflect on outcomes.

AR provides a methodology to determine if an online learning environment can be an effective and efficient space for students to develop skills and knowledge. Various authors, such as Watson (2008) and Wright (2010), have identified the main advantages of online learning as the any-time, any-place access it provides as well as the effectiveness and efficiency of online formative assessments. Using a qualitative AR approach provides a framework to determine how well an online environment can support students' learning outcomes.

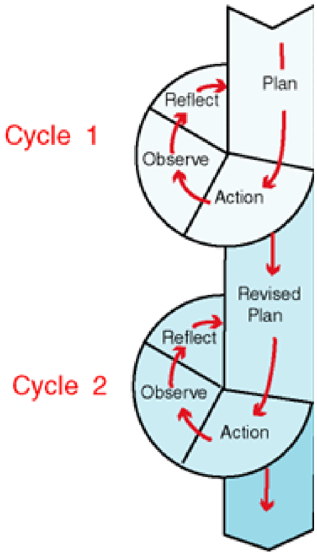


Figure 3.1 Action Research Cycles (Clark, Nute, & Zellerer, 2001)

This study used a traditional form of AR based on Lewin's "spiral of cycles" (McTaggart, 1991). These cycles of planning, acting, observing and reflection as shown in Figure 3.1 provide a base for research that is flexible and responsive. These non-linear cycles are a framework to plan, develop the first action step, implement the first action step, evaluate it, revise the general plan and start the second cycle. This AR process can be both proactive and reactive (Craig, 2009).

The proactive research process (Craig, 2009) is when the researcher uses his or her own expertise to identify potential problems and then uses systematic inquiry to determine solutions. The reactive research process is when the researcher identifies an existing problem and normally through participant feedback or observation, conducts a systematic inquiry to solve the problem. This cyclic process supported the development of this online course. It is impossible to ensure that an implementation can be perfect and the “spiral of cycles” provides the means to improve current practice.

In this study, these AR cycles provided a vehicle to develop the online robotics course for senior secondary high school students. The researcher used both proactive and reactive research processes (Craig, 2009) to determine changes to the next cycle. Through the reactive research approach, participant reflections and discussions were used to evaluate each cycle and revised plans to improve students’ learning. The researcher also used a proactive research approach to determine other suitable changes to the online course and decisions about the AR cycles.

3.3 Methods

This section addresses the methods used in carrying out this research. Before starting the data gathering phase the researcher considered several areas to ensure validity of the data and ethical considerations were taken into account. The role of the researcher and the selection of the school and participants have also been discussed. The learning environment used in this study has been described and how data was collected and triangulated through observation, forum interaction, and formal and informal interviews are discussed. Finally, the resources used and the study timeline have been outlined.

3.3.1. Validity and Credibility of Data

One of the most important tasks of the researcher is to ensure the data is valid and reliable. In qualitative research validity can be addressed through truthfulness, depth and scope of the data, the type of participants, triangulation and the objectiveness of the researcher (Cohen et al., 2011). This improves the trustworthiness of the data obtained. Reliability in qualitative research shows how well the data reflects what has actually happened in the researched environment. To ensure the reliability or credibility of the data, three elements need to be addressed:

- Following rigorous methods when collecting and analysing data

- Credibility of the researcher which means using her training, background, experience and presentation of self to ensure valid and reliable data
- Philosophical belief in the value of qualitative enquiry (Patton, 2002)

Yin (2010) describes three objectives to build trustworthiness and credibility in a qualitative research study. The first objective is to ensure the research is publicly accessible so that others can review and critique the research study. This is called transparency. In this study transparency is ensured through publishing the results from this study. The second objective is to ensure the research is done methodically. Although there is scope for discovery and unanticipated events in a qualitative study, it is important to follow a set of procedures to ensure all aspects of the planned research has been covered to an appropriate standard. The use of rigorous methods (Patton, 2002) to ensure a reliable study have been outlined in this chapter. The third objective is the adherence to evidence. This means that results from students' reflection, teacher and researcher reflections and interview transcripts need to be analysed and triangulated to ensure validity and reliability of data. Triangulation was used to validate data and to ensure that biases in the data can be overcome. This provided improved confidence in the data (Cohen et al., 2011). This technique involved gathering data from different sources (students and teachers), using different types of data (observational field notes, interviews, forum interactions etc.) and using research theories to support the findings (Creswell, 2012; Davidson et al., 1999). "The inquirer examines each information source and finds evidence to support a theme" (Creswell, 2012, p. 259). This ensured that the study will be more accurate and that the report on the study be accurate and credible as it draws on multiple sources of information.

Further to this is the importance of member checking of interview data to ensure interviewees agreed with the data as the researcher interpreted it (Holly, Arhar, & Kasten, 2009). The transcripts for the teacher interviews were summarised and given to the interviewees for member checking which they all subsequently signed.

3.3.2. Ethical Considerations and Approval

Ensuring the data collected is valid and reliable is not the only consideration for the researcher. All researchers should have a moral and ethical awareness that guides their behaviour (Hopkins, 2008) when dealing with human beings. At the University of Canterbury, the Educational Research Human Ethics Committee (ERHEC) provides principles and guidelines researchers have to follow to ensure appropriate moral and ethical behaviour and minimal risk to participants. These include having informed consent from the participants, guaranteed confidentiality of all data and participants, no unnecessary deception, minimal risk to participants and to be consistent with the Treaty of Waitangi obligations (The Educational Research Human Ethics Committee, n.d.). The individual rights of participants with respect to privacy, confidentiality, anonymity, safety and right to withdraw and issues around maximising the benefits of the study whilst still addressing student rights and ensure everyone is treated fairly are discussed below. In addition to the research focus ethics, the researcher is also cognisant of ethical issues around online learning as discussed in Section 2.8.3, which need to be considered to uphold credibility of this study.

It is the responsibility of the researcher to ensure that privacy, confidentiality and anonymity are upheld. According to Mutch (2005) privacy is ensured by not asking questions outside the scope of the research, not asking private questions or giving the students a feeling that their time has been wasted. Confidentiality and anonymity can only be guaranteed by the researcher as far as personal discussions and publications are concerned. The purpose of any study is to disseminate the findings as widely as possible so anonymity of all students can be achieved by using pseudonyms and keep the name of the school confidential. This should minimise the risk of identifying participants. Participant students' safety in this study could only be an issue with respect to emotional or cultural harm and they were able to discuss this with their classroom teacher or school counselling service if it becomes a problem. A code of conduct was used to manage this and is shown in Appendix 3.

There are some other ethical dilemmas that may create conflicts and internal tension in qualitative research. After students have agreed to participate and then decide to withdraw in the middle of the study, there needs to be a point where their data can still be used to avoid complications for the researcher. The main problem here is that their online discussions, which are either self-initiated or part of other students' discussion threads, may have already influenced the outcome of a specific discussion. One way to ensure that the researcher still has enough data to work with even after some participants may withdraw is to involve the whole class in the ethical process but then choose specific participants at the end of the course for individual interviews. The classroom teacher also has a right to withdraw, which may also complicate matters. His/her opinions form an important part of the study to support the students' data and verify credibility of the results. Fortunately, none of these situations transpired in this study.

Toprak et al. (2010) outline the importance of instructional ethics to ensure all participants have an equal chance of succeeding whatever their background is. So, if the online course did not provide all students with knowledge and skills they needed to successfully complete the assessment, the researcher in this study had an ethical responsibility to fall back to the face-to-face approach although it may impact on the results of her study. Further to this is the fact that the researcher was involved with the class, initially visiting some of the class sessions before taking on the role of substitute teacher for reasons explained later in the document. She also brought her own expertise and teaching style that may have changed the results. This change in role to substitute teacher from teacher assistant can also create an ethical dilemma between the overall aim of the study and students' successful learning outcomes. Using the objectives outlined above to ensure trustworthiness and credibility helped to minimise this ethical dilemma.

The students in this study did not have a choice in using the online environment for learning but they had the right to decide if their participation data could be used as part of an educational research project. Through face-to-face classroom discussions these students were informed of their rights in the study and all the appropriate documented ethical clearances was obtained from the ERHEC (31 May 2013), the school principal (31 May 2013), the classroom teacher, and six students and their parents/caregivers. The information and consent forms are included in Appendix 4. Gaining informed consent was a critical part of the research project to ensure all participants understand the purpose of the study, how it will be conducted as well as how the data will be used (Mutch, 2005).

As part of the online course environment, the participant students in this study knew each other and their usernames were their real names. The school's learning management system was a closed environment using passwords. The online course environment was closed to the rest of the school and access only granted on request. This did not mean that all discussions online were totally private as network administrators, and potentially hackers, were able to access those if they chose to. Confidentiality also relied on participants respecting each other's privacy. All participants of the course were also able to access the course from home or other places outside the school environment.

This research was about the use of an online course in robotics for Y13 students. The researcher was also responsible for creating the online course. The students' main focus was to complete two NZQA assessment standards successfully, whilst the researcher's focus was to demonstrate how an online course could be a resource to support face-to-face teaching.

3.3.3. The Role of the Researcher

Understanding and being aware of the roles a researcher may have is a key part of ethical research. Clarifying these roles ensures that the researcher can attempt to ensure that conflicts of interest are declared or avoided (Educational Research Human Ethics Committee, n.d.) as well as having an awareness of prejudices and other biases that may affect the data (Bogdan & Biklen, 2007) through these various roles.

In this study, the researcher had three main roles. As the researcher she was a participant-observer and she also had an online course designer and teacher role. Initially, the researcher started as an outsider who developed the online course and became the assistant teacher. She attended some classes as the participant-observer, gathering data through observation and informal interviews and became familiar with the participants while gaining their trust. As the participant-observer she engaged with the observed students whilst they were working on their activities (Holly et al., 2009) This phase is critical for the qualitative researcher to ensure minimal role conflict and tension between the participants and the researcher (Cohen et al., 2011). The researcher mainly worked in a one-to-one situation, supporting the students in using the online course to learn the content. The classroom teacher was responsible for assessment and students in general.

On 14 August 2013, six weeks after the start of the course, the classroom teacher went on long-term leave for personal reasons. The researcher was offered and accepted the position of substitute teacher for this class. This changed the relationship of the researcher to the students as her new role was in a position of authority and altered the dynamics of this class and how the students interacted with the researcher and each other. It was evident that some students preferred the original classroom teacher. As the substitute teacher she had to continually encourage the students to submit assessments with which they had had trouble. This provided a tension in the relationship between the researcher and participants which may have subsequently influenced some of the data and results. Such tension and changes are not unusual in participant research and care must be taken to recognise challenges in a transparent manner.

3.3.4. Access to the School

Gaining access to a school is a process of negotiation (Walford, 2001). Although this researcher was offered access to the class by the classroom teacher who was a very experienced technology teacher and with whom the researcher had worked with over the years with the development of teacher resources as well as teacher professional development, permission had to be sought from the principal. The researcher had never worked in the participant school before this research project. This research was conducted with a Y13 group in a combined Y12/13 Electronics class in a single-sex, high decile, urban secondary school in New Zealand using an AR approach.

It was initially agreed with the classroom teacher that the teaching and assessment period will be from 24 June to 23 August 2013, an eight week period. The students were to complete their assessment reports after the teaching period. There were four periods per week of one hour duration. The researcher was supposed to attend only some of these sessions with her main aim to ensure the students could collaborate and interact with peers and the classroom teacher and researcher online. This was also to be the official data gathering period for this study. As outlined previously, this outcome did not eventuate.

3.3.5. Selection of Participants

It is common in qualitative studies that researchers select specific groups of people even if they do not represent the wider population. This is frequently the case in small-scale research. There are several types of non-probability samples that can be used to select participants (Cohen et al., 2011). In this study, purposive sampling was used to choose a group of Y13 Electronics students and gain access to a teacher with in-depth knowledge and experience of the research topic.

All 11 of the students in the Y13 group were invited to participate in the study. They had to access all the teaching resources online and it was expected that they engage with the online course. Participation in the research aspect of the class work was voluntary and informed consent was requested from all students. Of these 11 students, three were overseas at the time and only six returned their ethics forms. This allowed the researcher to use the online discussions, class discussions, reflections and assessment results of these six students to support the study. Using pseudonyms, these six were:

- Shaun, a practical student who preferred hands-on work and is a keen rugby player. He had previously completed the Y12 Electronics subject
- John, another practical student who just wanted to work with his hands. He had also previously completed the Y12 Electronics subject
- Frank, an academic student who can achieve to an Excellence standard. This was his first time taking an Electronics subject.
- Ryan, an average student who was taking Electronics for the first time
- Chris, a quiet student who wants to pursue a career in ICT. He had also taken the Electronics subject previously in Y12.
- James, who engaged well with programming of the robot, had also completed the Electronics subject previously in Y12.

From these participants, five students participated in the semi-structured interviews to further explore their learning and experiences. The regular classroom teacher, Mrs Brown, was also a participant in the study as her opinions and observations triangulated the student data. The researcher was also a participant and her reflective journal formed part of the data.

After initial analyses of the data, it was decided to interview three teachers from another large, urban secondary school with a strong e-learning culture to strengthen the study. The teachers Gaye, Val and Jason (pseudonyms) were interviewed to provide additional insight to the data collected in Cycles 1 to 3. Gaye and Val were interviewed because they have used a similar online robotics course the researcher developed in 2012 for Y10 students. Gaye was a very experienced teacher in Digital Technologies, especially Information Systems. She used the online robotics course with two consecutive Y10 classes in 2012. She had never taught robotics before and was keen to use the online course. Val was also a very experienced Digital Technologies teacher, especially in programming. She has taught Lego Mindstorms NXT robotics (Lego, 2011) in a previous Y12 programming course and used the Y10 online robotics course in 2013. Although Jason, who was the head of the Digital Technologies department at this school, did not use the Y10 online robotics course, he had a vast experience in e-learning and regularly contributes at national level within the field of digital technologies. He actively promoted the use of Moodle (Moodle Pty Ltd, 2014) at his school, as a tool for teachers to support their classroom teaching in a blended environment. They all have been involved at national level in the development of the Achievement Standards for this subject. These three teachers were given their transcripts and summary of the interviews for member checking and approval, all of which were subsequently signed. Subsequent references to the participant school will be “School A” and the other school, “School B”.

3.3.6. Learning Environment

Pearlman (2010) states that new learning environments are needed to support 21st Century skills. Using digital technologies and other Web 2.0 tools, students are able to work individually and collaboratively in project-based teams. Students want to learn through creatively developing new knowledge and skills and finding solutions to problems. In these new learning environments, teachers guide students to achieve individual learning goals rather than telling them what to learn and how to learn it (Pearlman, 2010). Replacing the traditional, production-style classroom with a blended classroom helps students develop 21st Century skills whilst still having a teacher to structure the learning until they are ready to take responsibility for their own learning. Blended learning environments create the opportunity for teachers to create individual learning plans to meet the needs for each individual student (Watson, 2008).

This study used a blended learning environment, to teach students about robotics. The researcher created an online learning course for robotics on School A's Moodle site to support the students' learning. The course unit plan is included in Appendix 5. The robot kits used were commercially available and came with extensive curriculum documents to support content in the online course. The context of the online course was based around an Antarctic theme and students were offered two NCEA Achievement Standards, AS91639 (Ministry of Education, 2012c) (See Appendix 6.1) and AS91640 (Ministry of Education, 2012b) (See Appendix 6.2). See Section 2.3 for more information. At the start of this robotics course, the plan was for the students to do AS91638 (Ministry of Education, 2012a) beforehand or as part of an external course in the week of the 26th of August 2013, however this did not occur.

The Moodle course, illustrated in Figure 3.2, consisted of a number of standard sections. The course was named "Robotics Interfaces" and there were two main areas: general topics and technical topics. The general topics provided administrative information for students about the online course and background information about the social use of robots in Antarctica.

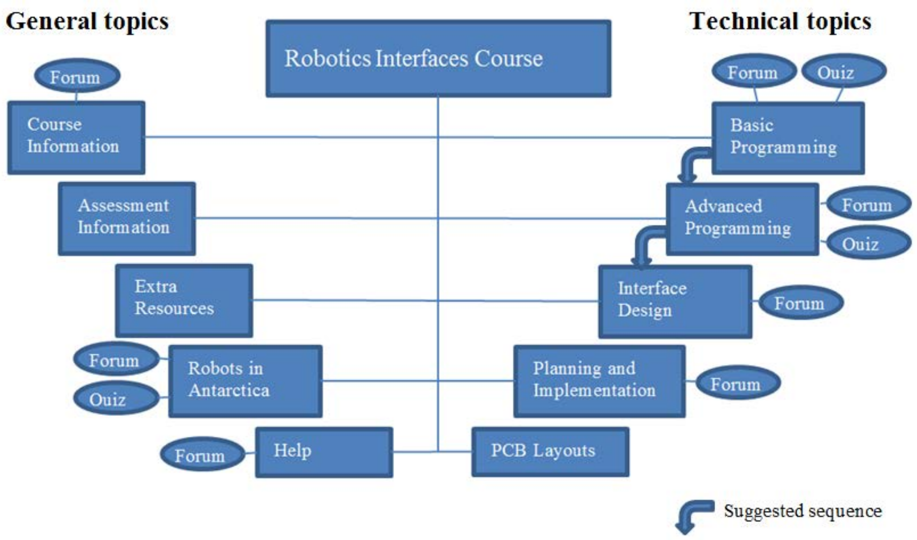


Figure 3.2 Course Overview

These topics were separated in the following areas:

- **General** - included the news forum and the synchronous chat room
- **Interesting** – included interesting videos about robotics

- **Course Information** – included the general course outline, instructions on how to navigate the course, students learning outcomes, information about e-Portfolios (Mahara, n.d.), participant responsibility, what they can expect of the teacher and links to general and social discussion forums and a table of the project groups
- **Assessments** – included detailed informations about the NCEA Achievement Standards
- **Robots in Antarctica** – included a Webquest about the use of robots in Antarctica, a discussion forum where the student had to discuss some open questions, individual task that required them to answer questions on their MyPortfolio and a quiz.

The technical sections were where the students found the course content required to successfully complete the practical activities of the course. These sections included:

- **Basic Programming -** included hands-on activities and component descriptions, information about programming structures and software errors, individual reflection on MyPortfolio, discussion questions and an end-of-topic formative quiz.
- **Advanced Programming** – included information on how to design programs with flow charts, agile programming, testing and debugging, how various advanced concepts are used in the robot's programming language, how to structure a program, information about serial data and motors and how to program stepper motors, individual reflection on MyPortfolio, discussion questions and an end-of-topic formative quiz.
- **Interface Design** included various advanced topics like two-phase stepper motor control, how to use shift registers, current and voltage measurements, temperature measurements, how to expand limited interfaces, how to add extra light emitting diodes to a circuit and a discussion forum.
- **Planning and Implementation** – included guidelines for the design proposal, develop the program and robot testing and writing the report.
- **Printed Circuit Board (PCB) Layout -** included references to circuit schematic capture and PCB layout applications. This section was not fully developed as none of the students were able to attempt AS91640 (Ministry of Education, 2012b) which requires a PCB layout.

Two additional sections were the Help and Extra Resources sections. The help section included the "General Issues and Problems" forum. The extra resources section included user guides and links to useful websites.

3.3.7. Data Gathering Process

The data gathering process is inherent to the AR design. The researcher use the cycles of reflective practise (act, observe, reflect) to collect data (Holly et al., 2009) in each. This study was implemented over three AR cycles with the Y13 participants in School A and an additional data collection phase through interviewing the teachers from School B as shown in Figure 3.3. The researcher observed the

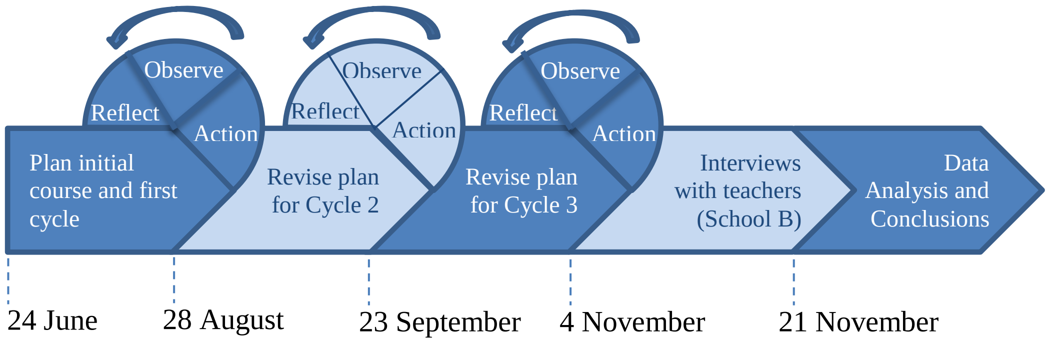


Figure 3.3 Action Research cycles for this study

students' interactions online and in the classroom and used unstructured interviews and observations to determine the students' engagement with the online course and to identify issues they had with the course. The researcher also had on-going discussions with the classroom teacher. This information was evaluated using both proactive and reactive research approaches to critically reflect on the weekly progress and experiences and how effective they were before revising the plan for the next cycle. Any changes made due to the feedback were documented as such. This "spiral of cycles" continued until the completion of Cycle 3. At this stage it was realised that additional information was required and, using the proactive research process, a decision was made to interview the additional teachers.

Action Research Cycle 1

The main focus for the first cycle was to introduce students to the online course and the different types of online interactions, as well as to get them to use the material to learn how to build and program the robots. The researcher enrolled all the students, distributed the ethics forms and explained to the students the layout of the online course. Students posted replies to the discussion forums. It was in this cycle that the classroom teacher went on leave (14 August) and the cycle ended on 28 August 2013. Adjustments were made and new content added to the course before the beginning of Cycle 2.

Action Research Cycle 2

The focus for this cycle was to help students with access to computers, ensure expectation for each section was clear and to structure the content of the Moodle course to include content sections for each page so that students were able to find information easier. The researcher also had to re-establish her role as the class room teacher in this blended environment. It was hoped that the changes made to the Moodle course would improve the students' experience. These were mainly superficial changes to do with addition of hyperlinks to important information on the main page. The week of 23 September 2013 was officially the end of the Cycle 2 AR phase. Again several adjustments were made before the beginning of Cycle 3.

Action Research Cycle 3

The changes made throughout Cycle 2 did not appear to have the desired effect of engaging students, so this cycle focused on why some students were disengaged with the online robotics course and how one student used the Moodle course more successfully. The researcher interviewed five students and the original classroom teacher to determine why they had trouble engaging in the Electronics subject. At this stage most of the students had not submitted any assessments for the Electronics subject. Many of the reasons for non-participation were reasons outside the researcher's control and are discussed in Chapter 4: Research Findings.

Following the responsive nature of AR, reflection of the Cycle 3 data showed that there was more to find out. At this stage it was the end of the school year and the Y13 students were on examination leave. Therefore, to strengthen the data, it was decided to interview three teachers from School B with a strong e-learning culture to research how they used e-learning in their teaching practice. So, in the next phase of this AR study, the teachers were interviewed to provide additional data.

Additional Data Collection

The focus for this phase was to interview three teachers for their perspectives on the questions of this research, based on their individual experiences. Through this process many of the reasons for the issues the researcher had with the research class became clearer and it became easier to extract themes when the new data was added.

3.3.8. Research Instruments and Strategies

The following sections outline the qualitative research instruments and strategies used to gather descriptive data. The instruments described are class room observations, forum interactions, student reflections and work output, quizzes, unstructured and semi-structured interviews, and the researcher's reflective journal.

Classroom Observations

Observation is a valuable tool in gathering qualitative data. It enables the researcher to systematically listen, watch and record what participants say, how they interact with each other and the activity they are engaged with (Scott & Morrison, 2005). In this study the researcher observed all classroom sessions she attended. Subsequent to every class she created audio reflections of all class discussions which were invaluable for on-going reflections. In this environment the researcher took on the role of participant observer (Creswell, 2012) to be able to interact with the students while they are working on their activities and helping them on a one-to-one basis. Working in an 'in situ' environment may make written field notes difficult when researchers are working with the participants, especially if they want to keep students' actions as natural as possible. Making the audio recordings immediately after each class made reflecting on and analysing the observations easier and more reliable as it is easier to remember what actually happened (Cohen et al., 2011). Obviously listening to recordings and reflecting on their content needs to be done soon after the observation period which the researcher has done as soon as possible after each class session.

On Line Forum Interactions

To help students develop their own knowledge, thinking and problem solving skills are essential (Lunney et al., 2008). Critical thinking skills are learned skills. Lunney et al. (2008) outline a process for using an online environment to develop these skills. Basically students learn through questions and answering these in their own words. Further to this, Lunney et al. (2008) also outline how the students need to create their own questions to further improve understanding. Critically analysing these discussions between instructor and peers, and peers to peers help students develop thinking skills. These discussions have a two-fold purpose. The first is for the student to develop their own learning of the subject matter. The other is for the researcher to analyse how effective these conversations were to the students' learning in general.

In this study, the students were expected to interact in online forums as part of each module of the course to develop their understanding of the topic. Plans to make students responsible for some of the forum questions did not transpire because of the reluctance of most of the students to participate online. Each week a different group of students was supposed to be responsible for the forum and lead the discussions. The researcher added starter questions to enable critical thinking and the students were expected to answer those. The students also had access to a "general discussion" forum and a "general issues and problems" forum and were expected to raise issues they had in these for the teachers or peers to answer. Five types of forum were used, each outlined below:

- **News Forum**
  The news forum was used to update the students with the focus for each week as well any other information they may need including letting them know of upcoming assessments or if there were any changes in the online course in separate posts.
- **Social Forum**
  The social forum provides the students with a place to build relationships, although they may need encouragement, which is especially valuable in the forming stages of an online course to create a sense of community (McInnerney & Roberts, 2004). The purpose is to initiate online discussions, which should help with the promotion of a more productive online learning environment. The main advantage of the social forum is for the students to socialise in an informal manner.
- **General Discussion Forum**
  The purpose of the general discussion forum was for the students to ask questions that are not linked to any of the other forums.
- **Help Forum**
  The purpose of this forum was for students to asked questions when they have a problem with the robot or programming issues.
- **Technical Forums**
  The purpose of the technical forums are to develop students' understanding of the technical content of the course. There were five discussion forums set up for each part of the course: Robots in Antarctica, RoboCircle and basic programming, advanced programming, interface design and planning and implementation. Each forum had specific question for the students to discuss except the planning and implementation forum that was for issues the students may have planning and implementing their projects.

Students' reflections

Reflection is a means to provide evidence of the understanding of learned knowledge and skills. The students in this study were required to reflect on an on-going basis on their e-portfolios to demonstrate their motivation, academic growth and level of achievement (Norton & Wiburg, 2003). None of the students were previously enrolled to the online e-Portfolio website, MyPortfolio (Mahara, n.d.), a New Zealand online e-Portfolio website used by most schools. Each section of the online course outlined expectation for reflections on their e-Portfolios. The participant students had weekly tasks to develop their skills using the robots. Students were expected to record their results through video, audio and/or capturing of the programming and other data. These examples form part of the study as that shows students' understanding and knowledge development and how well they achieve their learning outcomes as outlined in Appendix 5.

Quizzes

Online quizzes can ideally be used for formative assessments in the classroom. With Moodle quizzes there are various question types that can be created including multi-choice, yes/no, matching and essay-type questions. Within each question the question developer can add formative feedback for each type of question. Anderson (2009) found that both distance and in-class students benefitted from online quizzes as a flexible learning tool. The participant students were able to attempt these as many times as they want and they receive immediate feedback on their progress to improve their understanding of the topic. There were three quizzes developed in this course: Robots in Antarctica, Basic Programming and Advanced Programming that were used to determine student engagement.

Interviews

Interviews are purposeful conversations, between two or more people (Bogdan & Biklen, 2007). In this study, two types of interviews were used during this research. Informal interviews or discussions were used in class as a means to get feedback on specific issues during the study. Semi-structured interviews were used at the end of the study to get more in-depth data to answer the research questions.

Informal Interviews

With informal interviews, questions emerge from the immediate context and observations with no pre-determination of question topics or wording (Cohen et al., 2011). Informal discussions with the students in this study occurred in class-time and were included in the researcher's reflection notes. These discussions were used to evaluate the course and change the course where needed. The students were interviewed informally in class in the first few weeks of the course. The references to these interviews are in the form, "student name", Interview 1, "date of interview".

Semi-structured Interviews with Regular Classroom Teacher and Students

The advantages of using a semi-structured interview approach is that we can used open-ended questions to determine the interviewee's point of view rather than influencing what they say through structures and meanings imposed by the researcher (Scott & Morrison, 2005).

The participant students, the original classroom teacher and the additional teachers from School B were interviewed for this study. The purpose of the 30-minute, end-of-course face-to-face interviews with the robotics course participants and their initial classroom teacher were to gather data with respect to their experiences in the course and how they perceived it went. They were asked some specific questions as starters (See Appendix 7). In the interviews some of these questions were expanded to improve understanding. The researcher's main focus was to determine and understand why the students did not engage in the Electronics subject in general. The three additional teachers were asked about their experience with e-learning and then they were asked their viewpoint on the research questions for this study. The references to these interviews are in the form, 'student name', Interview 2, 'date of interview' or 'teacher name', Interview 1, 'date of interview'.

Researcher's Reflective Journal

The researcher's reflective journal includes descriptive and reflective field notes, to record what has happened as well as personal thoughts and views on the descriptions and processes (Creswell, 2012). In this study, the researcher kept a journal of all issues relating to the research. These descriptions and reflections have been recorded in the researcher's journal on an ongoing basis both in class as well as afterwards, away from the research context (Cohen et al., 2011).

3.3.9. Resources Used

Table 3.3.1 below shows the resources used in this study. The online Moodle course used in this study was especially developed for this research, based on a robot supplied by Robokits Limited and purchased by the school. For the development of this course the researcher used her own resources.

Table 3.3.1 Resources Used

Resources	Detail
Online Course	Moodle site hosted by Research School
Robots and other hardware	Provided by Robokits Limited and researcher
Student access to online course site	Laptops/PC's – provided by school and own devices
Researcher's computer	Access to internet, word processing and other documents

3.3.10. Timeline

The participant students were involved in the research study from 17 June to 4 November 2013. The main learning phase for the students through the robotics course was up to 6 September after which they were expected to complete the assessment project. In this time, they could access all information on the Moodle course and interact in all the forums. The itemised plan for this study is shown in Table 3.3.2.

Table 3.3.2 Research Study Timeline

What	When	How
Research proposal	1 May 2013	Senior Supervisor/HOD's approval Submit document to Associate Dean of Postgraduate Studies by 1st May
Ethics clearance	31 May 2013	Submit to EHRC
Ethical approvals	2 August 2013	Letters to School, teacher and parents Discussion with students
Create online course	May/June/July 2013	Upload current resources to Moodle Create new resources to upload to Moodle Code of conduct for online discussions
Teaching period	24 June to 6 September 2013	Mainly online teaching period
Collect data	24 June to 4 November 2013	Collected data via forum discussion, reflections and end-of-course interviews
Cycle 1	24 June to 28 August 2013 (7 weeks)	Course introduction and teaching period
Cycle 2	29 August to 23 September 2013	Improve student learning experience

What	When	How
	(4 weeks)	
Cycle 3	24 September to 4 November 2013 (4 Weeks)	Interview students
Additional phase	8 to 21 November 2013 (2 weeks)	Interview additional teachers
Transcripts	31 January 2014	Transcripts from audio recording, interviews of participants and extra teachers
Analyse data	February to April 2014	Synthesise themes and coding of data
Final Thesis	December 2014	Structure results and complete document

3.4 Data Analysis

This section outlines the data analysis theory, initial themes and the process of extracting the themes. The first step is to organise the data through coding structures and then providing initial themes to analyse the data. The process of extracting themes for this study provides an initial starting point for Chapter 4.

3.4.1. Coding

Analysing qualitative data requires disassembling, organising and labelling the raw data using coding techniques to find patterns and themes, clarify the data to find meaning and explaining these themes and patterns (Cohen et al., 2011). Cohen describes three types of coding when analysing qualitative data (2011). Open coding is when the data is examined and categories and subcategories identified to show similarities (Creswell, 2012) in meanings, feelings, actions etc. The next phase is to sort the data in some order. This is called axial coding and is done by selecting one category and determining its relationship to the other categories (Creswell, 2012) and the original labels and links to the literature is made (Cohen et al., 2011). The third phase is selective coding and is when a core or main code is selected and its relationships to other codes is made clear and the results is compared with existing theory (Cohen et al., 2011).

3.4.2. Initial themes

To determine how effective an online course is, Chang (1999) suggested the use of the Web based Learning Environment Instrument (WEBLEI). The WEBLEI use four areas to measure this effectiveness as outlined below:

- **Access** (Emancipatory activities):
  This area shows the convenience, efficiency and autonomy with which students can access the course material. This indicates how effectively students can access the Internet and how much the student felt in control of his/her own learning and how comfortable they are with that control. If too many students feel there is too much work it is a good time to change/tweak the course. In this case modifying some activities to be extension exercises help the majority of the students to keep up.
- **Interact** (Co-participatory activities):
  This area shows how easy students could reflect, receive feedback and collaborate. This is a vital area for effective online learning and student learning outcomes. It is important that when students are online they can productively interact with their peers and teachers.
- **Response (**Qualia):
  This area show how students felt about the course. If the student enjoys the course there is a greater potential for learning. One specific question "Do you think you would like to learn more about robotics as a result of this course?" is important to ensure the feedback here is positive because the ultimate aim is to have more students in the technological fields.

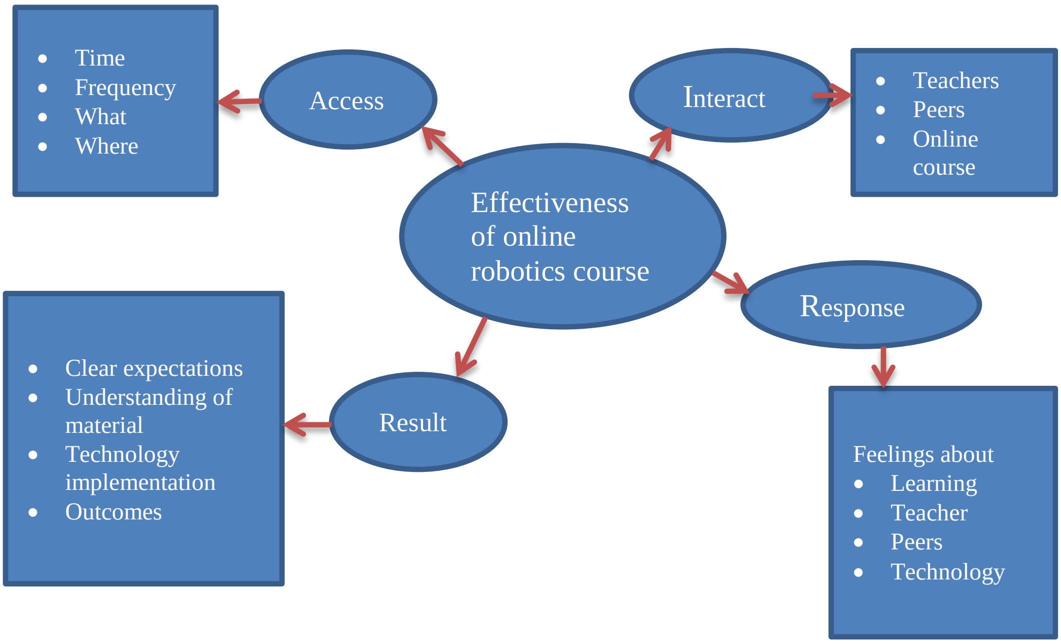


Figure 3.4 Themes and codes for data analysis (as derived from (Chang, 1999))

- **Result (**Information structure and design activities):
  This area shows how well the online course supported the students in achieving their learning outcomes. This indicates whether the students accomplished any of their leaning objectives by using the learning resources provided in the online course. These are the practical aspects of the course (Chang, 1999).

More information on each area can be found in Appendix 2. Using information from the WEBLEI tool (Chang, 1999), the above themes can be coded as shown in Figure 3.4 to provide initial themes for the data analysis in this study.

Reflecting on the data occurs at every stage of the AR process (Cohen et al., 2011). This concurrent ongoing nature of data analysis is important because the researcher continually "looks for emerging questions, themes and patterns throughout the study" (Craig, 2009, p. 164). This is to ensure the overarching research questions will be answered and improvements for the next cycle of the research process can be addressed.

In this study, the researcher analysed the data gathered from classroom observation, online forums, the researcher's journal and interviews at the end of each cycle to determine themes and coded the data initially according to the themes outlined by (Chang, 1999).

3.4.3. Extractions of the themes

During the data collection phase the researcher continuously reflected on possible themes. Initially, the data showed some themes in line with Chang (1999), for example access and the students' response to e-learning and learning in general but by Cycle 2, other themes including student engagement, self-motivation and prior learning were emerging. These themes continued during Cycle 3 with the students' interviews. The next phase, interviewing the teachers from School B, provided better evidence that there was benefit in using an online robotics course for both students and teachers. These teachers' perspectives emerging were access, self-management, teacher attitude, and student literacy. These themes aligned with the initial themes that emerged from Cycle 1 to 3 which were access, self-management and student engagement, the role of the teacher and prior knowledge and skills.

In the next phase more formal axial and selective coding was done to extract the final themes. This additional analysis of the data was done through creating mind maps of the key findings over each AR cycle and then the additional data gathering phase (in future this will be referred to as the data gathering phases). Even after this easily identifiable themes were not clear. Only after the researcher created a cross-cycle analysis matrix of key findings over the data gathering phases did clear themes emerge. Closer investigation of the data revealed that student engagement was a major factor that influenced the students' success in using the online course and that the themes extracted are in effect all "sub-themes" under student engagement. These themes were: access to the online course, the students' background knowledge and skills, how students interacted with the course and students' internal drive or conation. Table 3.3 shows the development of these themes.

Table 3.3 Progression of Themes Extracted

Data Analysis	**After Data Collection Cycles**	**After Additional Teacher Interviews**	**After Mind maps of key findings (During Coding)**	**Cross-cycle analysis for final themes**
Themes	Access Self-management, Student engagement The role of the teacher Prior knowledge and skills.	Access Self-management Teacher attitude Student literacy	No clear themes	Access to the online course The students' background knowledge and skills Students' interaction with the course Students' internal drive or conation

3.5 Chapter Conclusion

This chapter introduced the rational for the research methodology and the methods used in this study. A description of the research methodology was outlined with a description of qualitative research, including a description of the interpretive paradigm and the epistemological stance of the researcher, and how AR is used within a qualitative study. This chapter includes the validity, credibility and ethical issues that need to be considered and how the school and participants were selected. The role of the researcher has been discussed. A description of the online course used and the data gathering process have been provided. An outline of the various research instruments and strategies used to gather data were described. The data analysis process has been discussed and initial themes outlined that will be further developed in the next chapter.

Chapter 4: Research Findings: Results

4.1 Chapter Overview

This chapter describes the qualitative results of this AR study at a large urban secondary school (School A) based on the use of an online robotics course in a blended classroom. Four distinct themes, extracted during the data analysis phase, were found to be major contributing factors to student engagement. This study found that reliable access to the online course, the students' background knowledge and skills, their interaction with the online course and their internal drive or conation influenced their engagement with the online course. In the following sections the research results are described for each of these themes, using the framework shown in Figure 4.1. The data descriptions also include the barriers that influence student engagement in each of these themes.

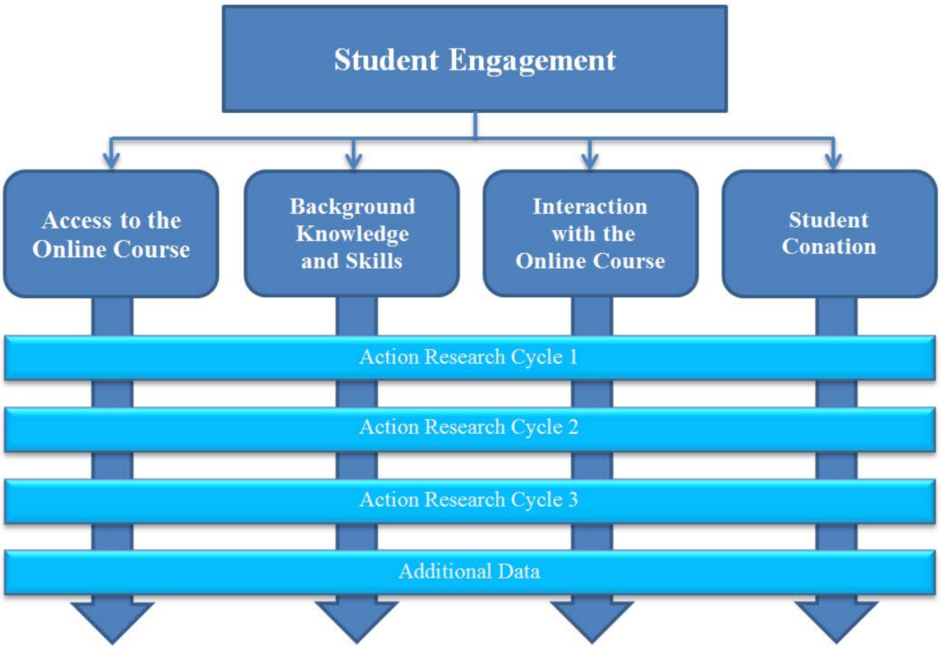


Figure 4.1 Structure and Organisation of Chapter 4 by Theme

4.2 Access to the Online Course

Reliable access to a course is one of the key requirements for successful online learning to prevent loss of students' interest. The technical tools the students need to enhance the learning process must be up-to-date, reliable and easy to use (Garrison & Kanuka, 2004). To ensure students are able to access the online course effortlessly they need effective and efficient access to the Internet and the Web. The difference between these two terms, as used in this study, has been outlined in the Glossary. This section outlines the research finding in four areas of access: hardware and network infrastructure access, access to the online environment, the frequency of students' access to the online course and laptop security. These areas all influenced student engagement in the online course investigated in this study.

4.2.1. Impact of Network Infrastructure and Hardware on Access

The network infrastructure and hardware, or Internet for short, impacted significantly on the students' learning in a number of ways. Reliable Internet access is critical to the success of online courses and this includes acceptable Internet connection speed (dependent on the network infrastructure) and computer hardware suitable for the assigned task. It was apparent early in this study that Internet access was one of the key barriers to student engagement because, when interacting in an online environment, using technology with a slow response time discourages students from using the online course as found by Sun, Tsai, Finger, Chen, and Yeh (2008). The following paragraphs outline the issues the students had to access the Internet with acceptable connection speed and the results of moving to a computer room to improve Internet access.

The Internet connection speed was problematic in the wireless hubs in the Electronics classroom of School A. For example, one of the early activities was to show a You Tube video about life in Antarctica as part of the unit ignition to assist students' understanding of conditions for their potential robots. During this session the video stopped playing every couple of minutes due to the slow Internet connection resulting in the students' loss of interest (Researcher's Journal, 17/6/13). Another issue was that the response time of the Internet connection slowed when too many students tried to access the school network. In this combined Y12/13 class there were about 22 students with a small number using their own laptops and the remainder sharing 12 outdated class laptops. In most cases the first five students who logged onto the wireless network were able to work online with few issues but by the time the tenth student logged on, the response time of School A's network became extremely slow.

To overcome the problem with the Internet connection speed in the Electronics classroom, a computer room with wired internet access was booked for the next period. This initially seemed to be a much better environment for the students as the researcher, in her role as teacher, was able to show everyone present (John, James, Chris and Frank) the outline of the course and the students were able to navigate around the online course and post replies to the online forums. Unfortunately, this did not seem to help, because by Week 2 of Cycle 1, Ryan (Interview 1, 3/7/2013) was asked, whilst in the computer room, what he thought about Moodle and his response was "Moodle is good but the Internet itself is slow". This was also found with opening the graphics-rich PDF documentation for the robots which were uploaded to the Robotics Moodle Course. Some documents took a long time to open and some computers could not open them at all (Researcher's Journal, 3/7/13).

When the students returned to their normal classroom after the computer room bookings concluded, they continued to have issues with the Internet connection. For example, on 2 August some students were still trying to log in after 15 minutes in the class (Researcher Journal, 2/8/14). In Cycle 2, the computer room was used more frequently to provide more reliable Internet access for students to complete assessment reports. This, however, did not seem to be particularly successful in helping students for example, John was not allowed on the Internet because of prior misuse of Internet access and all the students inefficient use of class time which is discussed in Section 4.5. Access continued to be an issue during Cycle 3 when the students were back in their normal classroom. For example, on 16 October they could not log onto the local server with the laptops when the Internet was down. They were only able to log onto the school network after 20 minutes into the lesson. The students had the same issue on 18 October. On 21 October, the students were in the computer room again to work on their assessment reports. Ryan did not want to work on his document because he did not have a word processor application on his laptop and he did not want to use a school computer "because it is crap" (Research's Journal, 21/10/13). During his end-of-course interview he said: "The school laptops and Internet access are horrible. Probably lost half a year logging on" (Ryan, Interview 2, 25/10/13).

It was assumed by the researcher that when specialist facilities in School A were used, the Internet access issues would disappear and the students should be able to complete their assignments. Yet, in spite of booking specialist facilities unreliable access continue to thwart progress. While the hardware and software in the computer room were adequate for the assigned task the students still had trouble engaging in the task. Internet access was less of an issue at School B as they had an established high speed broadband network using fibre. Since 2010, they had dedicated personnel to improve and increase the use of ICT in the school wide community. Although School A has been focusing on developing teachers' and students' ICT understanding and capability, this was not evident because of the issues described. Ryan (Interview 2, 25/10/13) commented that "Moodle is a new thing for everyone" although Mrs Brown (Interview 1, 14/10/13) said in her interview that the students were given training in the use of Moodle for learning three to four years ago.

4.2.2. Access to the Online Environment

Being able to effortlessly and reliably access the online environment (the Web) is another key requirement for student engagement. There were two main issues that were frustrating for both the researcher and the participant students. These were the need for multiple logins maintained on the school network and registering to MyPortfolio (Mahara, n.d.).

Logging onto the Web

Logging on to School A’s network and the Web was frustrating for the researcher although the students did not specifically mention this as an issue. The researcher found that logging onto the school network was frustrating because it required the user to first log onto the school network (when onsite), with separate logins required for each of the following: the web browser, the e-mail account, Moodle and MyPortfolio. A more desirable scenario is the same login for all as at School B, as it is time consuming to have to log in numerous times especially with a slow network. This issue was particularly evident to the researcher as she had worked in another school where an open ID system was used, allowing access to multiple websites with one login account.

MyPortfolio

The researcher’s original plan was to use the online MyPortfolio (Mahara, n.d.) site for student reflections and showcasing their learning. Unfortunately, registering to the MyPortfolio site was not so easy for the students because when they registered they needed to check their school e-mails regularly which they were reluctant to do. This was necessary because approval came in their school e-mail inbox, anywhere from one to five days later and students had 24 hours to respond. Due to the students not checking their school e-mails regularly, the registration requests expired and they had to do it again. Even the researcher had to register twice because she forgot to check her e-mail at School A over a weekend. When the researcher discussed this in class, Shaun, one of the participant students, commented: “That’s bad” (Researcher Journal, 10/7/13). In the end only three students (Frank, Ryan and John) were registered but they did not use MyPortfolio for reflection although they were shown how to do it (Researcher Journal, 7/8/13). When students were asked at their interviews about their use of e-mails, Shaun (Interview 2, 18/10/13), who did not have Internet access at home, said he was new to e-mail, Frank (Interview 2, 30/10/13) said it was a secondary e-mail he checked once a fortnight, Ryan (Interview 2, 25/10/13) said he did not use the school e-mail as there was too much spam on it and Chris (Interview 2, 30/10/14) only checked it at school.

4.2.3. Frequency of Students' Access

The frequency of the students' access to the online course was a major concern. The Moodle activity, checked daily, and participant students' attendance statistics are shown in Figure 4.2. Students attended this class four periods a week with a total of 36 periods in the data gathering phases. Although these numbers may have a margin of error, it shows the significance of this issue. For example students with a score of one for Access means they had only accessed the online course one day in that week. This was also reflected in their class attendance. The participant students were not in class often enough to make progress on a task and because most did not do homework (See Section 4.5.2), progress was limited. Another issue was that at the end of each period the students locked up

													Exam							
	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8		Week 9		Total/36	
	Access	Attendance	Access	Attendance	Access	Attendance	Access	Attendance	Access	Attendance	Access	Attendance	Access	Attendance	Access	Attendance	Access	Attendance	Access	Attendance
James	0	2	1	3	1	2	0	1	2	1	0	0	1	1	0	0	1	2	6	12
Ryan	0	2	1	4	1	1	0	3	1	1	1	0	0	1	2	1	3	3	9	16
Chris	0	1	1	1	2	0	1	1	1	2	2	3	0	0	0	0	1	0	8	8
Frank	0	2	1	0	4	0	2	3	2	3	5	3	4	1	5	2	1	2	24	16
Mrs Brown	0	4	0	4	1	2	1	0	0	0	0	0	0	0	2	0	0	0	4	10
Shaun	0	2	2	2	3	3	3	1	2	3	3	3	0	0	1	2	0	1	14	17
John	0	2	1	3	0	2	1	2	1	2	4	3	0	0	1	2	0	0	8	16

Figure 4.2 Student Attendance and Moodle Activity

their robots and laptops in the cupboards in the classroom and then sometimes forgot their keys the next period, which meant they lost more time learning to program their robots. This appeared not to bother them. This may link with the students' conation which will be further explored in Section 4.5.

4.2.4. Laptop Security

In an attempt to overcome the problem of outdated class laptops, the original classroom teacher, Mrs Brown, encouraged the students to bring their own laptops but the students were reluctant to do so because security was a major concern for them (Researcher Journal, 7/7/13). Although the classroom teacher provided them with lockable cupboards in the Electronics classroom, the students did not want to use these because when they attempted to retrieve their laptops after school, the classroom was normally locked (Researcher Journal, 28/6/13).

4.3 Background Knowledge and Skills

Early in this study it became clear that the students had difficulty using the online course and lacked some basic knowledge and skills that the researcher believed the students should have had to be able to complete the assessments for the robotics online course successfully. To understand the influence this had, two areas were evaluated: the participant students' prior knowledge and skills in electronics, including supporting subjects, and their knowledge of and skills with online tools to support their learning.

4.3.1. Prior Knowledge and Skills in Electronics

Before the researcher created the online robotics unit, she was given the Electronics subject course plan (of which the robotics unit was a part), assessments offered to the students for this course and the textbook the students used. With this information the researcher made assumptions about the students' prior knowledge and created the course. This section describes the influence of the course plan, assessments and the text book on the students' ability to complete the course and the individual students' pathway into Electronics.

Course Plan

The Electronics subject course plan for this subject showed what the students were supposed to know before starting the online robotics course (See Appendix 8). The topics outlined in the course plan indicated to the researcher that even with a basic knowledge of those concepts, they should have been be able to understand the information in the robotics unit. The difficulty students had in completing their assessments for the robotics unit as outlined in the next section may have been avoided if they had a better understanding of the topics outlined in the course plan.

Assessments

The students' record, of completing assessments, is explained here because they may have influenced their interaction with and their perceptions of the online course. Therefore, further to the information outlined in the course plan, the assessments due before the start of the robotics unit indicated that the students should have been able to understand the information outlined in the robotics unit.

Unfortunately, by the beginning of the online robotics course only two participant students (Frank and John) had completed one of the assessments demonstrating an understanding of electronic components. The original due date for this assessment was 19 April but it was extended to 14 October by Mrs Brown. This generous extension impacted on subsequent learning later in the year. On this date, James asked for another extension (Researcher Journal, 14/10/13) and he was granted an extra day. Another assessment about robotics interfaces (AS91638) was given to the students on 24 June for completion by 9 August (Researcher Journal, 24/6/14). This assessment was about specific theoretical background information for the robotics online course unit and should have been completed before the start of the online robotics course. Only Frank successfully submitted this report on the last day after the researcher evaluated his draft reports numerous times and provided feedback (Researcher Journal, 4/11/13).

It was the first year Achievement Standards were offered in the Electronics subject and understanding of the assessments proved to be a major barrier for these students. They were able to attempt three different standards on the robotics topic although only two were offered as part of this online robotics course unit. The first standard, AS91638, required a demonstration of the students' understanding of complex concepts in the design and construction of a robot system. It is about the theoretical functioning of various parts of the system and how they function together. Although it was beneficial for the students to have this completed prior to attempting AS91639 (See Appendix 6.1), it was not essential. The AS91638 is an external standard (See Glossary) that should have been completed outside the context of the online robotics course. When students were supposed to complete AS91639, for this online robotics course they still had trouble attempting the first standard. The later standard is a practical implementation of the robot system. There was a lot of confusion with these standards. Although the researcher verbally explained the differences between the standards and added extensive explanations on the online course site (Researcher Journal, 30/8/13) some students chose not to access this information. None of the students attempted AS91640 (See Appendix 6.2).

Text book

Apart from the Electronics subject course plan and assessments, the researcher used the class text book as an indication of the prior knowledge of the students. The researcher assumed that the student have used this book for their learning which proved not to be the case. The Electronics textbook the participant students used was first published in 1985 with the second edition in 1997. Although a bit outdated, especially the photographs, it still contained detailed descriptions of a wide variety of electronics concepts, components, circuits and systems as well as measuring instruments. The level of these explanations was used as a starting point in creating the robotics online course. The text book also included information required for assessments about electronics components that the students had trouble completing. The researcher also realised that the students had issues understanding basic motor theory which was explained in their text books (Researcher Journal, 7/8/14).

Pathway into Electronics

Another factor which appeared to influence students' understanding of the context of this course was their pathway into the Electronics subject. This includes the digital pathways for students through their secondary schooling and previous courses taken in electronics. School A did not have a pathway from Y9 for students in digital technologies, including electronics. The Y9 students at this school did a basic electronics introduction unit as part of a combined technologies course over a trimester. The next time they were able to choose Electronics as a subject was in Y12. Some were allowed to take the course for the first time in Y13. This meant that students enter this subject without the knowledge and skills to be successful. The research school's Electronics teacher, Mrs Brown, the original classroom teacher, believed most students took this course with a hobbyist approach. Therefore they did not have the appropriate skills to successfully complete this subject. She was critical of the school's attitude towards digital technologies and believed many of the students should not have been accepted in the course because of their lack of prior experience (Mrs Brown, Interview 1, 14/10/13). When the researcher commented to Jason (Interview 1, 19/11/14), from School B, in his interview about the need to start at Y9, he replied "you have to start at Y9".

4.3.2. Online Tools

The online robotics course was not just about robotics but was intended to help develop other 21st Century skills, through their use of an online course, which are valuable skills for the future (Bellanca & Brandt, 2010). In this course the participant students were expected to interact online through forums, use Moodle as a learning platform, and reflect using e-Portfolios. This section outlines the issues the participant students had, in using online tools for learning and their skills in using those.

The students were expected to participate in the Moodle course through activities, forums and quizzes and e-Portfolios to reflect on their learning. Chris was the only student who had done an online course before and believed that he would have no issue with it. Unfortunately because he did not need the credits for NCEA, he did not participate in the course (Chris, Interview 2, 30/10/14). Although the students had used information on Moodle before, they had not used it for two-way interaction. The researcher provided detailed explanations about expectations for creating reflections in their e-Portfolios including using design principles to improve their presentation but this did not assist participation (Researcher Journal, 7/8/13). This may have had more to do with students' conation as outlined in section 4.5, although Val, a teacher from School B, commented that students needed to learn to reflect and the researcher had expected them to know how to do it (Val, Interview 1, 8/11/13). Ryan (Interview 2, 25/10/13) commented in his interview that it probably would have been a lot easier to use Facebook as students know that well.

The teachers from School B who were interviewed in the additional data gathering phase, especially Jason (Interview 1, 19/11/14), emphasised the importance of teaching the students the use of Web 2.0 tools from Y9. Gaye, another teacher from School B, agreed and described how she needed to teach students how to use Wikis before they could use them for reflection as part of the robotics unit. With the next class she decided to use MyPortfolio (Mahara, n.d.), which was a much better choice as the class had been using it throughout the year. Putting evidence in the form of videos and reflections on MyPortfolio became an easy, natural process rather than them thinking about it. Gaye (Interview, 21/11/13) also found that although there were students who had done really well with the Wikis, the fact that they had to learn how to use it first, distracted from the robotics learning. She suggested developing those skills in Y9 and Y10 was better because they do not have the threat of formal assessments as they will have in Y11, 12 and 13 with NCEA. Gaye also believed at Y10 students cannot have only online courses. A good balance of online and face-to-face learning (the blended classroom) with the teacher as the facilitator was more successful (Gaye, Interview 1, 21/11/13).

4.4 Interaction with the Online Course

Evaluating the way in which the students interact with an online course illuminates how effectively they are engaged in the course content and how motivated they are to complete activities (Lynch, 2004). This section describes the participant students' interactions in the online forums and the quizzes. Most students interacted at the start but by the end only Frank was active in the online forums and found it beneficial. The interviews with the additional teachers showed many insightful aspects of using online courses. Gaye suggested that she had more success with her students interacting in an online course by using a range of strategies such as Skype, Wikis, e-Portfolios and other Web 2.0 tools. Jason and Val also contributed to understanding the impact online learning has on both teacher and students for example with simplicity of online courses. The study findings are outlined below for how students interacted with the content of the online course, their use of online tools and the simplicity of the online course.

4.4.1.Online Content

The course content for the online course was created on Moodle and structured around course and assessment information, activities and assessment tasks. Using Moodle makes access to course content easier because the information is all in one place (Shaun, Interview 2, 18/10/13). This section shows how the online content influenced learning with respect to student literacy, diversity and interactivity.

Literacy

Literacy proficiency may have been the reason why most of the participant students were reluctant to read course documentation. For example, James posted replies to the forums without reading the question first which he admitted to (Researcher Journal, 19/6/13). He also made the comment on 25 October that it does not help reading the assessment documentation as he still does not understand what to do. He was told that he had various opportunities to ask. They were instructed many times in class to read through the information online (Researcher Journal, 6/9/13; 17/9/13; 21/10/13; 24/10/13; 25/10/13) but only Frank showed any indication that he has read it. The information included the assessment documents as well as the clarifications. The students also appeared reluctant to read through all the activities to test different functionality of the robot.

Both Val and Gaye made comments in their interviews about the role of literacy in online learning. Gaye believed students in Y10 are speed readers who will scan over the text and only pick up text that stands out like bold formatting (Interview 1, 21/11/13). Although the lesson plans were provided in each period, both as part of the Y10 robotics online course and on the data show, the students did not always read and comprehend what they had to do (Val, interview 1, 8/11/13). Jason (Interview 1, 19/11/13) believed students do not want to read, except when they had to answer a question.

Diversity

Diversity describes the range of students' abilities in the classroom. One of the teacher's responsibilities was to cater for all abilities. This can be a huge challenge. The participant students had a range of self-management and learning abilities that needed to be catered for. Frank was highly-motivated, able to effectively work at home and was able to achieve high grades. Ryan and John were not able to manage themselves to do homework, work effectively in class or complete this course successfully. Val had similar issues with her Y10 class who had a huge range of self-discipline, self-management and self-motivation levels that she had to work with. She believed there was more for her as a teacher to do, to make the students think about what they are doing (Val, Interview 1, 8/11/13).

Gaye believed the online robotics course could advance students' learning by catering for diversity. Extension work provided the able student with opportunities to progress quicker than others. She believed it is, however, important to reward students with exercises that extend their learning rather than more of the same thing. Gaye modified the original icebreaker worksheet, used to familiarise the students with the online environment, into two parts which worked much better (See Appendix 9). Gaye (Interview 2, 21/11/13) used modelling with the class while the more able students moved onto the advanced worksheet.

Val said that the Digital Technologies class were mixed ability classes mainly in three groups. The able students who just wanted to continue at their own pace, the middle group who needed a lot of pacing and help and the ones at the low end that "got lost after the first two sentences". Val felt the online course catered well for diversity in student abilities as it enabled the teacher to spend time with some students while others continued on their own (Val, Interview 1, 8/11/13), as was also experienced by Gaye.

Interactivity

Interactivity involves the actions or input from a person using the online course and the resulting feedback or reply he or she receives. Moodle has the potential to provide an interactive learning environment, instead of using it as a repository. The participant students usually accessed information on the Electronics subject course page on Moodle which was used as a repository. Jason (Interview 1, 19/11/13), from School B, said "even using Moodle as a receptacle of information (repository) is better than using a structured network drive as it becomes complicated to navigate multiple levels of folders. It is easier to use hyperlinks in the Moodle environment".

Moodle allows students to take control, learning through a structured approach by working though blocks of learning, each building on the other. The participant students were able to interact with the online course through quizzes and forums. The results of their interactions are described in the next section. In his interview, Jason said he believed that to make the students responsible for their learning, an online course had to be interactive. Using online Moodle quizzes for the pre-tests, after each topic and at the end of the course ensures that students get immediate feedback on their progress (Jason, Interview 1, 19/11/13).

4.4.2. Variety of Tools

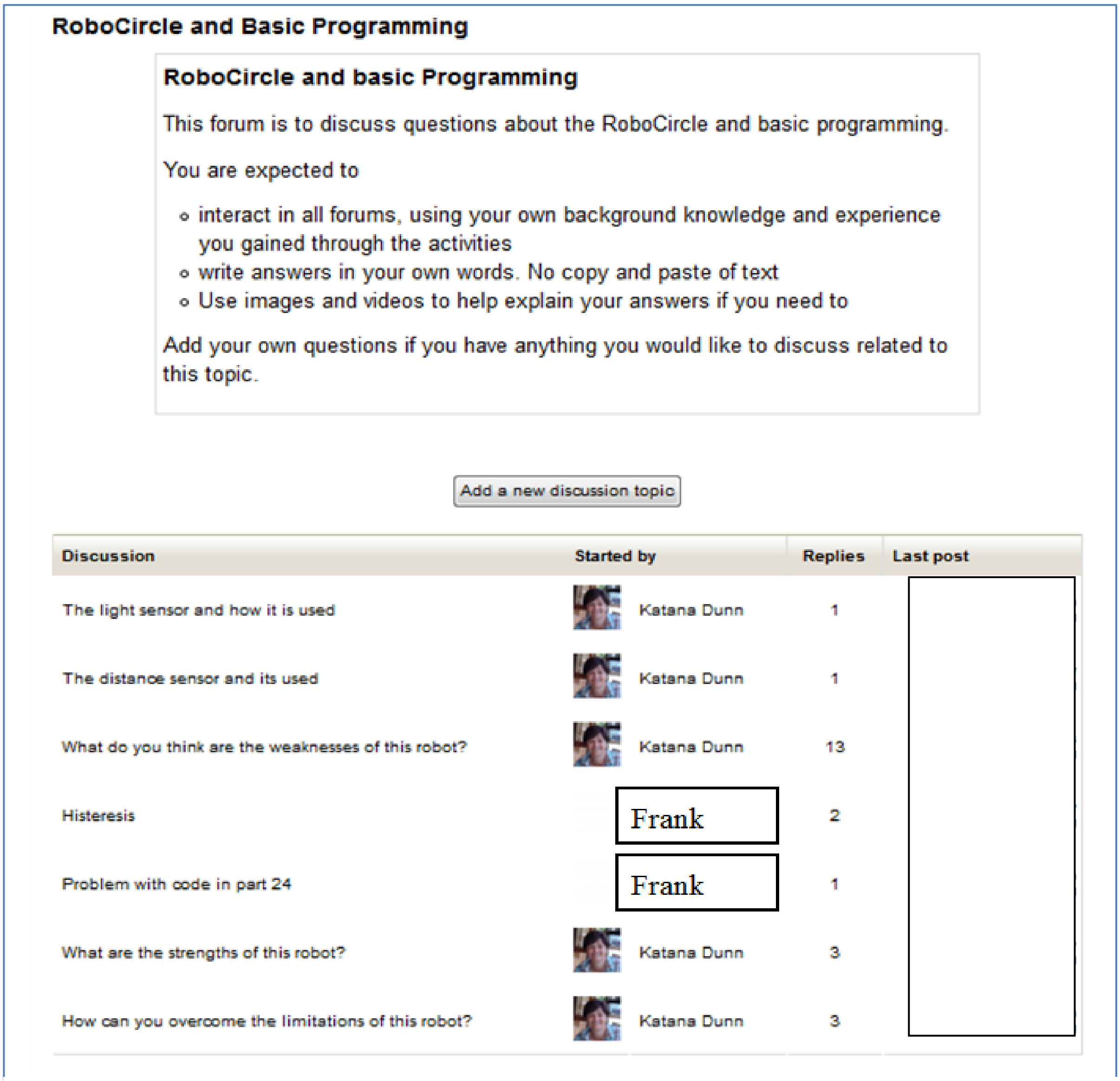
In this study various online tools were used by the participant students and the additional teachers interviewed. Online interactions were also used to support students with their NCEA assessments. The forum interactions were used by students to receive formative feedback to improve their learning. When Val was asked what aspects of on-line course design were successful for teaching robotics, she said the different variety of visual activities that students can re-watch and review in their own time (Val, interview 1, 8/11/13). This section describes how forums, e-Portfolios and quizzes were used in this study, and how the additional teachers used other Web 2.0 tools successfully.

Forums

Interactions in online forums provided students with opportunity to develop understanding of course content through collaboration as discussed in Section 2.8.1. Only Frank was successful in the forum for learning but Gaye from School B, with her Y10 online robotics course, showed good examples of students advancing their own learning through interacting on the forums. This section describes how the different types of forums (general discussion, help and technical) were used.

The general discussion forum was used to ask questions that were not linked to any of the other forums. Only two students, Frank and James posted to this forum although all students replied to the ‘Introductions’. In the ‘Introductions’ forum each student introduced themselves and their background knowledge in robotics. Frank, the able student, was the only student who successfully used the help or general issues and problems forum. Frank was also the only student who posted to the technical forums. Examples of his interactions are shown in Figure 4.3 and Figure 4.4.

Gaye had more success with her group of Y10’s interacting in the forums but only after appropriate teaching had taken place. During the first round of the Y10 online robotics course Gaye had issues



RoboCircle and Basic Programming

RoboCircle and basic Programming

This forum is to discuss questions about the RoboCircle and basic programming.

You are expected to

- interact in all forums, using your own background knowledge and experience you gained through the activities
- write answers in your own words. No copy and paste of text
- Use images and videos to help explain your answers if you need to

Add your own questions if you have anything you would like to discuss related to this topic.

Add a new discussion topic

Discussion	Started by	Replies	Last post
The light sensor and how it is used	Katana Dunn	1	
The distance sensor and its used	Katana Dunn	1	
What do you think are the weaknesses of this robot?	Katana Dunn	13	
Histeresis	Frank	2	
Problem with code in part 24	Frank	1	
What are the strengths of this robot?	Katana Dunn	3	
How can you overcome the limitations of this robot?	Katana Dunn	3	

Figure 4.3 Example of forum interaction with Frank

with students using the forums, especially not replying to previous posts but just creating new ones. The next round she spent time showing them how to use it and how to reply to existing posts before the start of the course. She made sure everyone was able to do it. Some students loved to solve problems for other students which helped the more able students to extend themselves. They were able to create a question in the help forum and using the snipping tool and labels to describe the problem and the answer. This was a technique Gaye (Interview 2, 21/11/13) taught the students previously in a desktop publishing unit and the students were able to transfer the knowledge.

Figure 4.4 Example of forum interaction with Frank

Gaye shared an example of how the Y10 students engaged in the topic and created a forum interaction without teacher input. One group of students posted a question in the Help Forum and another group answered it as shown in Figure 4.5. See the use of labels to describe what the solution is. This was not an easy question and even the researcher did not know the answer without spending time investigating it. It showed that the teacher can be the facilitator and provide the structure but the students were able to take their learning to the next level. Gaye said "the forums did need education. They needed to be educated to use the forums wisely." She made sure the students were able to use the forums correctly and deleted inappropriate postings. She started with something really simple that they could answer to gain confidence. Monitoring the forums closely taught them what to do (Gaye, Interview 1, 21/11/13).

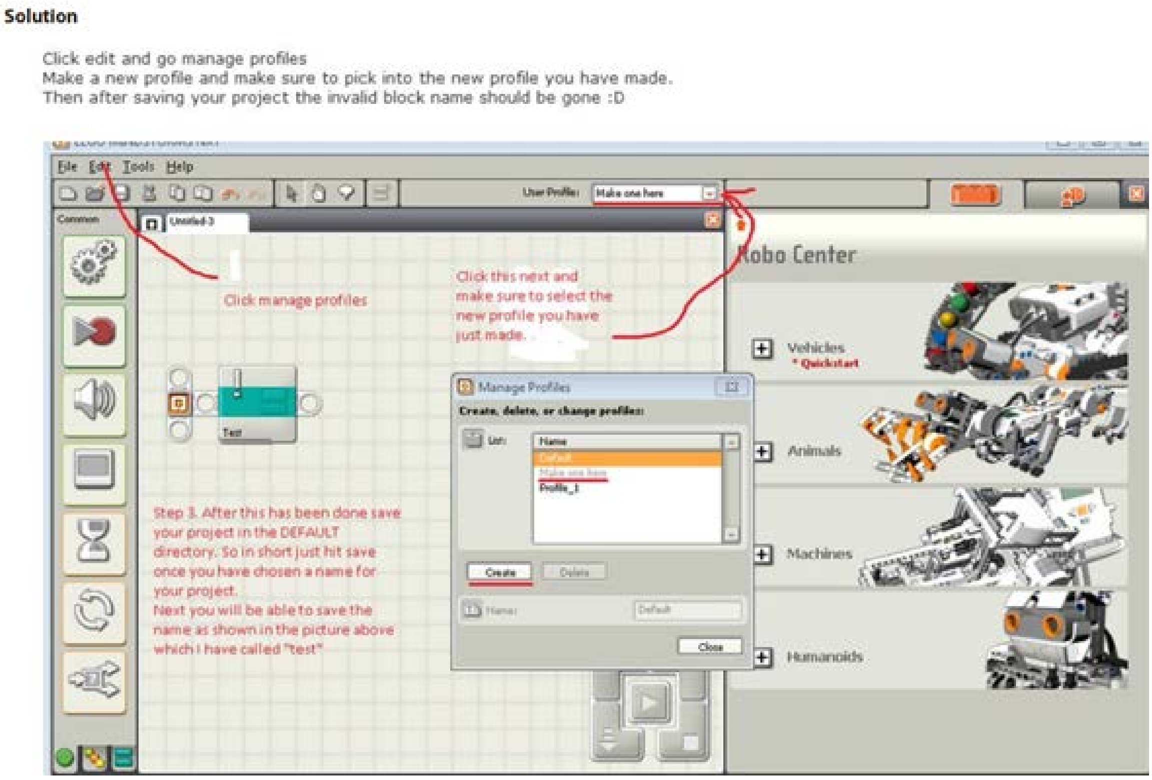


Figure 4.5 Answer to the MyBlock name issue

E-Portfolios

E-portfolios can be an effective tool for students' reflection and to showcase evidence of student learning. Students can take screen shots of their work and write reflections where reflections need to be written (Jason, Interview 1, 19/11/13). Unfortunately, none of the three participant students who were able to access the MyPortfolio website used it, although they were given instructions on how to use it (Researcher Journal, 7/8/13). Val said "they just don't know" how to reflect and write reports and needed to be taught those skills. They must have the skills to make videos and use e-portfolios before starting the robotics online course. When they started the course they only wanted to go to the practical bit and build the robots (Val, interview 1, 8/11/13).

Gaye had more success using e-portfolios and the students were very proud of their e-portfolios and she noted some were “really fantastic”. Gaye (Interview, 21/11/13) was able to show teachers from other schools at a common meeting, examples of an advanced, average and non-achieving student. The other teachers were amazed how much even the non-achieving student was able to do.

Quizzes

Quizzes are another tool that can be used effectively for formative assessments (Anderson, 2009). Three quizzes were incorporated in the robotics unit and each quiz was between 5 and 14 multi-choice, true/false, matching and embedded answers questions. The results for each quiz in this study are summarised in Table 4.1. Students were able to attempt quizzes twice. Some of the students, although they have been continually reminded, chose not to complete the quizzes as can be seen in Table 4.1. Over the period the number of students attempting the quizzes also decreased.

Table 4.1 Quiz Results in percentage

Name	**Robots in Antarctica**		**Basic Programming**		**Advanced Programming**	
	First Attempt	**Second Attempt**	**First Attempt**	**Second Attempt**	**First Attempt**	**Second Attempt**
Shaun			30	70		
John	100				35	90
Frank	100		70	100		
Ryan						
Chris	100		35		80	
James	80					

Gay and Val, the teachers from School B, had more success measuring student achievement using the Y10 online robotics course. Student achievement was measured through quizzes, observation, student questions in forums and their e-portfolios or Wikis. Gaye said in her interview she did no marking throughout the whole course but did it all at the end. She said getting the students engaged with quizzes from the beginning, especially if they get good results motivated them to carry on. Even if the first quizzes did not provide explanations with each answer (formative), Gaye (Interview 2, 21/11/13) thought they were beneficial in engaging the students. Although Val (Interview 1, 8/11/13) had to keep encouraging her students to do the quizzes, they worked very well because the results contributed to the students' grades.

Other Web 2.0 Tools

Although they were not used in this study, this section describes other Web 2.0 tools like Skype, Voki, Tagxedo and Google Docs that were used successfully by the teachers from School B. Using Skype as a way to communicate with subject specialists, can be used by classroom teachers to help students with the course content (Skype, 2014). For example, Gaye used Skype with her second class to contact the researcher at home so students could ask questions. She had a video link displayed on the data show. This meant students got immediate answers for their problems or ideas on where to look. Some of these questions were later summarised in the help section for other students' reference. Engaging with students in this manner provided extra opportunity to progress especially because Gaye (Interview 2, 21/11/13) had never programmed a robot before.

In Gaye's class, the students loved making a Voki (Oddcast Inc., 2014) and Tagxedo (Leung, n.d.). Vokis are virtual avatars that could be used to explain concepts in robotics and what they were learning. Gaye suggested that most students did not like writing and preferred recording their voices for the Voki. Tagxedo turns words into a visual word cloud in any shape or colour and can be used to show good knowledge of words students were using. Even the less able students enjoyed using this tool. Students, who can expand this, adding their own shapes and take their learning to a higher level, could do it for homework and it counted for grades (Gaye, Interview 1, 21/11/13).

Jason developed activities in Google Docs for students to work through on their own, before going to Moodle to do the quiz and moving to the next level. He said the teacher can just look at the online grades and no marking is required because they are automatically marked. Also, with Google Docs, Jason indicated that students were able to share their documents with the teacher who displayed the work to the rest of the class using the data show. This allowed students to be involved with peer assessment. Computer marking and peer assessment freed the teacher so that he/she can spend time teaching bigger projects and the supplementary learning is coming from these activities. This has advantages for both teacher and student. Moodle is the instructional base. "So, Moodle, Google Docs, Wikis and e-portfolio all have their own purpose" (Jason, Interview 1, 19/11/13).

4.4.3. Simplicity

Simplicity may have had an impact on student engagement and the participant students had different perceptions of the complexity of the course. In the one hand, Chris (Interview 2, 30/10/13) felt the online course was not too difficult and the amount of reading was not a problem as he said he can always use “Ctrl-F” to find information. On the other hand, Ryan (Interview 2, 25/10/13) felt there was too much information and that it was confusing. Frank (Interview 2, 30/10/13) thought some students had problems because the information was too detailed, and they did not have the required background knowledge, but he did not have a problem with it and it was what the standard required. James suggested adding hyperlinks on the main page to the current tasks and class news to make it easier for students to find information (Researcher Journal, 9/9/13).

The teachers from School B supported the idea of simplicity in course design and structure. Val did not believe the issue was online courses itself, but in general. “Students have a ’butterfly mentality’ where they ‘flick, flick’ through the information and if they don’t like it, they move on. They want it easy and simplistic. They don’t persevere to ensure they understand what needs to be done” (Val, Interview 1, 8/11/13). Jason believed online courses advance students’ learning by not using too many steps to get to an outcome. He also said that aspects of online course design that are successful for teaching robotics (or other courses) are instant answers and clear appropriate use of technology for the right outcome (Jason, Interview 1, 19/11/13).

While there appear to be a tension between simplicity and the development of higher thinking skills, this is not the case. An online course site that is user-friendly can provide a structured environment to develop higher order thinking skills.

4.5 Student Conation

The NZC identifies five competencies people need to contribute as active members of society (Ministry of Education, 2007). These are thinking, using language, symbols and text, managing self, relating to others and participating and contributing.

From this study it was evident that the participant students did not exhibit the key competencies at a level that might be expected of students at their final year of secondary school. Being able to manage yourself is a key skill to complete a task successfully. Self-management is associated with self-motivation or conation which is defined as an instinct, drive, wish or craving to act purposefully (Merriam-Webster, 2014). In this study, the participant students had to be continuously reminded to complete assessment tasks. Although some of the reasons for disengagement had to do with their background knowledge and skills, another reason may have been the students' own conation as described in this section. There were a number of indicators related to students' conation. These were school and class culture, student work ethics and attitudes, teacher attitude, and the students' reasons for completing this course.

4.5.1. School and Class Culture

One of the fundamental influences on student engagement is the learning culture in a classroom (McGee & Fraser, 2012). The students' own assumptions, values and believes and their attitudes towards learning also contribute to their success (See Section 2.5). This study was impacted by the classroom culture set by the classroom teacher and heavily influenced by the school-wide culture. The original classroom teacher, Mrs Brown, generally had a good relationship with the students and the students relied heavily on her for content guidance and problem solving. When the researcher became the substitute teacher, most of the students found the change in teacher philosophy and teaching styles disruptive to their learning and it was difficult for them to continue being engaged with their studies. The students expected the researcher to provide a lot more guidance and the researcher expected the students to be more independent, self-directed learners. Therefore, this study was not an impartial observation of an ordinary classroom setting, but a class unsettled by change. The evidence of this culture is described in terms of the students' work ethics and attitudes.

4.5.2. Students' Work Ethics and Attitudes

The students' work ethics and attitudes influenced their engagement in this course. The section outlines the impact of the students' work ethics and attitudes towards learning and assessments, towards each other, school property, assessments, homework and the use of digital technologies.

Towards Learning and Assessment

The participant students found it difficult to use class time effectively and efficiently. Students were engaged while constructing the robot kits but when undertaking programming activities they had trouble staying on task. For example, Ryan had to be reminded to stay on task on many occasions (Researcher's Journal, 7/8/13, 8/8/13, 9/8/13, 23/8/13, 23/9/13 and 25/9/13). The students, especially John, tended to be talkative, loud and the discussions were normally not related to the topic

(Researcher Journal, 6/9/13). Another example of the students lacking motivation was shown by Shaun. Although he could see the benefits of online learning and he thought it was easier than face-to-face classes, he did not engage in the course. When he was in class he found it difficult to work on the activities and because he did not have Internet connection at home he was not able to complete any tasks or assessments (Shaun, Interview 2, 18/10/13). John (Interview 2, 24/10/13) said he did not learn anything in this course, because he did not log onto the online robotics course and did not put enough effort in.

One of the frustrating experiences the researcher had in her role as the substitute teacher was the students' attitude towards completing assessments. The students seemed to think that postponement was acceptable possibly because of messages received from their original classroom teacher, Mrs Brown. For example on 9 August the students were supposed to complete a draft report, but Mrs Brown postponed this by telling the class "let's look closely at it on Monday". Only two students (Frank and John) had submitted one assessment each to this point. The original course plan showed assessments were due 19 April, 17 May, 12 July and 9 August. This was changed to 14 October, 25 October, 25 October and 18 October by the researcher and Mrs Brown in the week of 10 September as no other students (except the two above) had submitted any assessments.

This attitude of "postponements are acceptable" was observed continuously as students worked through their robotics assessments tasks. They were expected to work through pre-activities to ensure they had the background skills to complete the assessments successfully (Researcher's Journal, 7/8/13). Students like Ryan frequently postponed working on the pre-activities until a few days before the assessment due date when they said they "just want to do the assessment". Unfortunately, they did not have the required background skills and some students then got frustrated because they had trouble with the assessment task. One example was when John's group could not get their robot program to work and asked why the researcher could not just help them "like Mrs Brown would" (Researcher Journal, 17/10/13). She explained that they should have worked through all the previous activities to learn the program that would have helped them to make the robot function properly and that trying to complete the assignment in one period was not possible. John wanted the researcher to give his group the code and although the researcher had example code which the students believed would work, it would not. The researcher explained that the code was created for a different robot design (Researcher Journal, 14/10/14). These students had not completed all the activities nor worked productively in the previous class sessions. As the due date loomed the students began to be serious about their assessment but for most, it was too late. Ryan commented in his end-of-course interview that "in most technologies if you have a problem the teacher sorts it out for you" (Ryan, Interview 2, 25/10/13). In her interview, Mrs Brown commented about the students' lack of self-management and personal accountability for their work. They seemed to find it easier to blame others when something did not go their way (Mrs Brown, Interview 1, 14/10/13).

Even after explaining to the students the requirements of these assessments in detail, students still had trouble completing the assessment due to a reluctance to engage with the material. For example, after one explanation, John asked that the researcher/substitute teacher tell him just one thing to complete for the next period (Researcher Journal, 30/8/14). When that was completed he expected the next and so on. Even Frank, the able student, had trouble and received a lot of feedback from the researcher to eventually achieve an 'excellence' level grade as appose to achieve or merit level. Although John submitted a draft report on Moodle in early September and feedback was given on the same day, he had not read the feedback and asked again on 24 October for an explanation of the standards (Researcher Journal, 24/10/13). A day later James had to be reminded of the requirements for the reports and was referred back to the Moodle course where it described what needed to be done to complete these reports (Researcher Journal, 25/10/13). Eventually when John was asked for the assessment at the due date, he said he wished to wait for his initial classroom teacher to return.

This lack of motivation was further observed in the end-of-year examination on 17 September. The purpose of the two-hour examination session was to complete their design proposals for AS91639 (See Appendix 6.1), which was the first assessment for the online robotics course. This was originally due on 6 September. In the examination session, which only four out of the eleven Y13 students attended, they were given a printed document outlining in detail how they should complete their design proposals. Even with the researcher showing an example of a design proposal, including the completed robot it was based on, these students, who were all participants in the research, experienced difficulty in completing the task. It also appeared that none, except Frank, had read the assessment documents and knew where to find them, because they kept asking basic questions.

Gaye (Interview 2, 21/11/13), one of the teachers from School B, made the comment, while she and the researcher were discussing the reluctance of some of the senior students in the research class to submit assessments on time that "self-management has to be taught". This was mentioned by the other teachers from School B as well.

Towards Each Other

The students seemed to have been in three distinct groups: Frank, Chris and the rest of the students. Frank was a quiet student, who was able to achieve ‘excellence’ grades in most subjects. Mrs Brown made it clear, on various occasions in class, that Frank and Chris were the only two students capable of achieving high grades in this course. The behaviour of the students towards Frank may have been influenced by Mrs Brown’s comments. Frank and Chris never seemed to talk or interact with each other or the other students in class. Some students frequently made remarks when Frank refused to speak in class. In one class, a student shouted at Frank because ‘apparently’ he could not get a reaction from him (Researcher Journal, 23/8/13). Frank ignored him but this incident might explain why he was always reluctant to work in class. The students seemed to ignore Chris the times he was in class.

Towards school property

The majority of the participant students seemed to lack respect for others’ property. This was observed through the state the robot kits were left in after each class, the way one group cut the plastic robot chassis to manipulate it into their design and the fact that they drew lines over the researcher’s vinyl activity mats.

A check of the robot kits in early September to ensure the sets were complete found parts missing and equipment left in an untidy mess. Some students had them locked up in the cupboards so it was impossible to do a complete check (Researcher’s Journal, 9/9/13, 20/9/13). Previously, John ‘butchered’ a chassis from one re-usable robot kit to make a construction that was different from the norm (Researcher’s Journal, 5/7/14). There appeared to be no consequence for this behaviour. In another period while the researcher was explaining to the students the different assessment tasks, John and one of the other students drew with blackboard markers on the black and white vinyl mats she brought for the class to test their robots on (Researcher Journal, 30/8/13). The researcher told them to clean it before leaving the class which they did. On the day of the practical assessment John, after asking if the assessment was due now, dropped the robot from his hand stretch above his head, because he believed the robot did not work anyway (Researcher Journal, 18/10/13). Because there was no damage to the robot the researcher did not follow this up but it did indicate an irresponsible attitude towards school property.

Towards Homework

Shaun (Interview 2, 18/10/13), John (Interview 2, 24/10/13) and Ryan (Interview 2, 25/10/13) stated in their end-of-course interviews that they have not done homework for this course. The main reasons students gave were after-school employment five days a week, playing sport and the fact that they did not see this subject as important. Frank usually did not work in class, (this may have been as a result of the students' attitude towards him) but he was the only one who worked at home. Val (Interview 1, 8/11/13), a teacher from School B, said that having access outside class did not ensure her students did their homework because they had to organise themselves to do it.

Shaun (Interview 1, 3/7/11) said he had no laptop and no Internet access at home although when the researcher spoke to him on 2 August he said he had a laptop but no Internet access (Researcher Journal, 2/8/14). Jason, a teacher from School B, stated that he believed that students who did not have Internet access at home were disadvantaged. At his school, students were able to and expected to access the Internet in the school library if they could not do it at home (Jason, Interview 1, 19/11/14). In Shaun's case he was the only one of the six participant students without Internet access at home. Although the students were expected to work at home, only Frank regularly accessed the online course outside school hours.

With the Use of Digital Technologies

It appeared the outdated computer hardware facilities at the participant school had an influence on the students' attitude towards digital technologies. Using Moodle as a learning tool was new to the school although they have been using it as an information repository for a few years. Most students did not use their school e-mails. Ryan (Interview 2, 25/10/13) said that the teachers will just tell them what they needed to know instead of e-mailing it. Another example of the school's use of digital technologies was the fact that the school absence register was taken online for the first time while the researcher was working at the school. This may demonstrate the low priority digital technologies have in the school as it could be expected that in 2013 online absence registers should be a norm for large urban schools.

4.5.3. Teacher Attitude

Teacher attitude can have a big influence on student learning. Successful teachers have a positive influence on students that are supported by the teachers' depth of knowledge and their own passion for learning (McGee & Fraser, 2012). The attitude and role of the teacher in an online or blended classroom is as important as in a face-to-face class. The teachers' role is to facilitate students' learning and guide them to a successful outcome. Their attitude will influence the students' experience.

In this study, the participant students experienced a change in teacher in the middle of their assessments. Mrs Brown, the original classroom teacher, a very experienced, electronics technology teacher at School A, was passionate about the importance of digital technologies as a career path. She also had a good relationship with the students. When the researcher became the substitute teacher she expected the students to be able to use the online course for guidance and instructions. The researcher's goal in her role as participant researcher and teacher was to develop the online course to support student learning as well as help students with specific problems. Unfortunately, due to the reluctance of most students to engage in the online material most did not have the knowledge and skills necessary for project completion and assessments. They expected the researcher to solve their problems and she did not believe that approach will be the ethical way to do it. She was only prepared to guide them.

In Gaye's experience (a teacher from School B) the online course design was successful for teaching robotics because the teacher did not need to have robotics knowledge. As she said: "It is giving the teacher knowledge they didn't have previously without feeling incompetent." As a teacher you have good skills and knowledge and the course can give you the confidence to teach a new topic. Gaye also had more success with the online course, than the other teachers, although she did not have any robotics knowledge. She was also passionate about using online learning because she believed it was the future and it was beneficial for the students for their own learning and for later in life. She was able to use the online environment and online Web 2.0 tools and help the students with their learning. She was always honest and told the students she did not know robotics and that they all needed to learn together. She believed an e-learning course she did a few years ago provided her with the skills, knowledge and experience to facilitate this course successfully. She also believes that if the classroom teacher is enthusiastic about online learning and is engaged in the content then it will be valuable to the students' learning. She made sure the students were able to use the online tools before the start of the robotics course. She also had a good rapport with the class and gave them opportunities to problem solve in previous topics. Not all teachers were successful at teaching robotics using the online course and Gaye believed it is important to have a teacher on-board who wants to teach the students robotics. Some teachers struggled to understand this. Gaye (Interview 2, 21/11/13) believed it is because the curriculum changed so much it needs projects like robotics to teach the skills needed. The teacher also needs to know the course well to be able to refer students back when they have questions (Val, Interview 1, 8/11/13).

4.5.4. Reasons for completing this course

Most of the participant students did not have good reasons to complete this course. Shaun was accepted on a rugby scholarship and left school early. Chris, John and Ryan already had enough NCEA credits (New Zealand Qualification Authority, n.d.) to continue on to tertiary study. Chris said he would have done it if he needed the credits. The only student motivated to successfully complete the course was Frank, who finished with high grades.

4.6 Chapter Conclusion

The comments from the teachers and other data indicated four main influences on student engagement in this course. This study showed that reliable access to the online course, the background knowledge and skills, interaction with the online course and conation were major influences to the students' engagement. With reliable access to the online course four areas were evaluated: the impact of network infrastructure and hardware, the student ease of access to the online environment, the frequency students accessed the online course, and laptop security. The students' prior knowledge and skills in electronics and with online tools were evaluated to determine how that may have influenced their understanding of the online course. Their interaction with the online course was described in terms of how online content influenced student learning with respect to student literacy, diversity and interactivity, how the students interacted with the variety of online tools and the simplicity of the online course. Finally, conation was explored in terms of the influence of school and class climate, students' work ethics and attitudes, the teacher's attitude and the reason students have for completing the course. Chapter 5 will discuss the results of this study by addressing the influence of course design, student considerations and course implementation on the online robotics course and students' learning.

Chapter 5: Discussion

5.1 Chapter Overview

This chapter discusses the results of the study and provides a framework within which to discuss the main research question: *How can an online course be used by classroom teachers, to teach a course in robotics in the senior secondary school?* The final chapter of this thesis concludes with a summary of the main research question and an evaluation of each sub-research question. The study identified three main areas to address when using an online course to teach robotics:

- The online course design; or how the course is structured to provide students with opportunities to develop their thinking skills, experiences and activities for learning and opportunities for conversation and interaction.
- Student considerations; or what the students bring to the course in terms of their own background knowledge and skills, their conation and their level of key competencies
- Course implementation; or issues that need to be addressed in the execution of the course such as reliable access to the online course, how students interact with the online course and the learning culture in the classroom and the role of the teacher during course execution

A successful outcome of the online robotics course in the blended classroom is also dependent on the wider school culture and positive attitudes towards blended learning (Zaka, 2012), as well as on the above factors as illustrated in Figure 5.1. The Ministry of Education (2014b) lists a range of factors

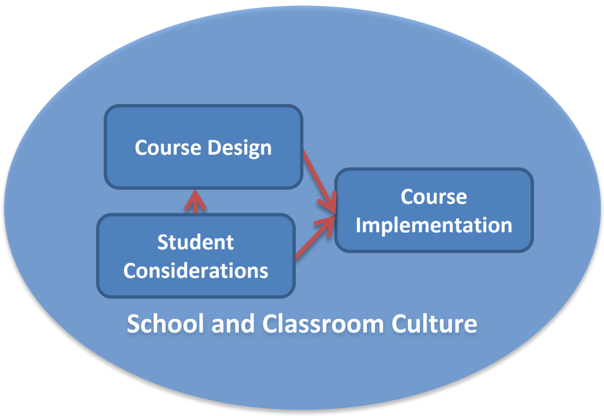


Figure 5.1 Factors influencing successful outcome of the online robotics course

that should be taken into account to ensure a positive learning culture. These range from the physical learning spaces, hardware and network infrastructure to the senior management, the school board and the wider community's attitudes and beliefs towards e-learning. This chapter discusses and illustrates the online course design, the student considerations and the course implementation in turn and weave in aspects of the school culture influence, where appropriate.

5.2 Course Design

Course design is a key component for effective pedagogy. Constructing an online course to engage students and develop their knowledge and skills requires the course designer to address four elements. There must be opportunity for students to think and reflect on their progress, learn through practical experiences and activities, learn through conversation and interaction (Dyke et al., 2007) and their prior knowledge and skills need to be considered. Using a learner-centred approach ensures that the diverse needs of students are addressed (Pachler & Daly, 2011). Considering these elements when designing an online course should enhance student motivation and satisfaction. Instead of simply being a repository of information, the online environment enables students to be in control of their own learning through reflections, practical activities, interactions and collaborations anytime and anyplace within a given context (Jones & Issroff, 2006; Tallent-Runnels et al., 2006). In this study, the researcher, as the course designer, considered these elements in the construction of the online robotics course. This section discusses the influence of course design with respect to students' thinking and reflecting, practical experiences and activities, conversation and interaction, and students' background knowledge and skills, on the online robotics course.

5.2.1. Students' Thinking and Reflecting

The ability to critically think and reflect is a key requirement to be able to design and develop products and systems used in real-world situations. Providing students with the opportunity to reason, make judgements and decisions, and problem solve will help them develop independent and interdependent critical thinking (Lunney et al., 2008). Therefore, it is important that the robotics online course facilitates the process of developing critical thinking skills, to enable a transformation of information and experiences into new knowledge and skills (Dyke et al., 2007). In this study, the online robotics course required students to use forums for discussions on various aspects of robotics and e-portfolios for students' reflections. Lunney et al. (2008) argues that Web 2.0 tools may be more successful in developing critical thinking skills than a traditional classroom. This may be because students have more time to reflect on the discussions and are able to draw on a wide variety of information through the Web. E-learning provides tools to encourage students to use reflective thought so they can develop their knowledge over time and adapt their thinking (Dyke et al., 2007) to a higher cognitive level. This was observed through the numerous forum interactions between Frank and the researcher to help him with his understanding of the robot functioning. E-portfolios also provide students with an online space where they can reflect on their learning, using their own words, by generating content showcasing their understanding of the topic (Mahara, n.d.). Although e-portfolios were not used by the students in this study for reasons outlined in the previous chapter, Gaye (Interview, 21/11/4) had more success with her class and was able to show that even non-achieving students recorded valuable reflections in their e-portfolios. Using e-portfolios caters for diversity and gives students opportunity to reflect at their own cognitive level through strategies that benefit all learning styles. Furthermore, students using MyPortfolio for reflections and forum interactions to articulate their learning in robotics and solve problems through discussions were able to advance their learning through scaffolding. This constructivist approach of scaffolding facilitates deep learning where students are able to take responsibility of their own learning (Stark & Woollard, 2011).

5.2.2. Practical Experiences and Activities

From the researcher's personal experience in learning and teaching robotics over a number of years, the best way to learn robotics is by doing. This constructivist, learner-centred approach provides students with authentic sequences of activities to develop their understanding of the robot functioning and to use the new knowledge to create robot designs. Dyke et al. (2007) equate this "learning by doing" approach to four stages: Experience, reflection, abstraction and experimentation. In this study, the students were expected to work through practical activities (experiences), reflect on their learning (reflection), construct new knowledge or determine how to use previous knowledge to design new robot programs (abstraction) and test their new programs in an authentic situation (experimentation). Although some students were only interested in specific learning outcomes for assessments, Frank was able to develop his knowledge of transferrable technology terms and processes through continuous effort as he worked through the four stages of learning, and completed the robotics unit successfully. He completed the practical learning activities and the Assessment Standard, based on this course, with an Excellence grade as appose to an Achieve or Merit grade. None of the other students successfully completed the assessment.

This way of learning robotics influenced the researcher's approach to the online robotics course design. The course included modular, clustered, interactive activities to facilitate the students' development of their knowledge and skills in robotics. These learning modules used a range of text, image and video resources to teach a variety of concepts with additional quizzes for formative assessment. This way students could re-watch, re-read or re-do aspects of the course whenever they wanted to. This provided the students with control over their own learning by choosing the pace, the sequence and the content they wanted to access in the online course. According to Chou and Liu (2005), students in control of their own learning achieve better performance. This approach also helps the students develop key competencies, a requirement to ensure people can contribute as active members of society (Ministry of Education, 2007) which is further discussed in Section 5.3.3.

In this study, the online robotics course was structured in a number of separate areas: Course information, assessment information and the main course area with the technical content that students work through to develop knowledge and skills. Each section had specific learning outcomes about technical content knowledge for the students to do. The use of hyperlinks in the online environment provided structured ways to organise the content so students could navigate the online environment and work through individual learning blocks either sequentially or in any order they wanted. Simplicity was an important concept here. Students like to find information easily and the resources or tools must be easy to use (Conole et al., 2007). In this study, there were some students who felt the course content was easy to do and locate, whilst others found the content confusing and thought there was too much information in each module. The data suggests that this closely links to student conation as discussed in section 5.3.2. Classroom observations, analysis of students interaction in the online forums and quizzes and the end-of-course interviews, showed that it was the students who had not worked through any of the activities, who found the course most confusing.

5.2.3. Conversation and Interaction

Using conversation and social interaction is a key aspect of the learning process in Technology Education (Dyke et al., 2007; Fox-Turnbull, 2010). Conversation and social interaction can help students make sense of the design process and construct new knowledge (Fox-Turnbull, 2010). In this course, this was achieved through the use of Web 2.0 tools such as forums. The participant students were able to interact in forums set up to develop critical thinking skills, attempt formative quizzes and submit assignments to online drop boxes. The researcher found online forums valuable as students were able to receive individual feedback, especially when the teacher is not able to help all students in the normal class session. Another advantage of the forums was that the students needed to articulate their problems, to get appropriate feedback, developing critical thinking skills in the process, rather than getting the teacher to solve their problems without them understanding their own problem. Frank successfully used online forums to develop his skills and knowledge of the topic through online collaboration with the researcher. Woo, Chu, Ho, and Li (2011) also found that the use of social networking tools provide a positive outcome for students to learn through content sharing and idea collaboration.

Another interactive feature was the Moodle Assignment drop box which was valuable for submitting assignments. The submitted information was always available (even if students lost the original document) and the grades with feedback were in one place which students were able to refer back to. For example, when John said he did not know what to do, he was referred back to the drop box where the researcher provided feedback the previous month, as described in Section 0.

5.2.4. Incorporating Students' Background Knowledge and Skills

Using diagnostic assessment activities and other student information enables online course designers to design courses that caters for differentiated and personalised learning to challenge and motivate learners at the appropriate level (Conole et al., 2007). In this study, the course site was structured to develop student's knowledge through modules of theoretical and practical robot activities. Using modular course design made it possible to create learning objects that catered for diversity of students with different learning styles, abilities and background knowledge and skills. It was important to evaluate the students' pre-knowledge of the content and their literacy (As discussed in Section 4.4.1) when designing an online course. Although the researcher took this into account, incorrect assumptions were made, as discussed in Section 4.3.1, which resulted in some students not having an acceptable level of background knowledge, to ensure successful completion. This reinforced the importance of carefully evaluating students' prior knowledge and skills to ensure successful entry to the online robotics course.

5.3 Student Considerations

To ensure the course design focus on the needs of the learners, the students' readiness for successful engagement in the online course in the blended classroom, needed to be considered (Zaka, 2012). Interestingly, Blocher, de Montes, Willis, and Tucker (2002), ask the following question about online learning: “Can anyone learn anywhere at any time or are there required prerequisite skills or strategies needed to achieve such learning?” (p. 1). This section discusses the influence the students themselves had on the course and includes students' background knowledge and skills in the course topic and Web 2.0 tools, their conation and their mastering of the key competencies as outlined in the NZC (Ministry of Education, 2007).

5.3.1. Background Knowledge and Skills in Electronics and Web 2.0 tools

Prior background knowledge and skills are key elements of successful student engagement. The knowledge and skills students bring to a course must be on an appropriate level to ensure the students will be able to construct new knowledge and skills through scaffolding from that base (Vygotsky, 1987). Therefore, online courses should be designed for the learners and consider their prior learning experiences with the content, and their confidence and competence in the use of computers and online tools (Beetham & Sharpe, 2007). In this study, most of the students did not have the expected pre-requisite knowledge of electronics and Web 2.0 tools, as described in Section 4.3, to ensure they could successfully complete assignments. Conation also strongly links with this issue and is discussed in Section 5.3.2.

One of the main advantages of an online course is that students can access it as many times as they want and the online tools can motivate and engage them to help improve their learning outcomes (Wright, 2010). For the students to benefit from this interaction with the online course, especially at the beginning, they need access to online activities that are easy for them to understand and build on their prior-knowledge. The belief that today's students are digital natives and know how to use digital tools does not mean they know how to use it for learning (Kolikant, 2010; Zaka, 2012). In this study, the students were expected to use online tools for their learning. With the online robotics course the participant students were able to revisit the information as many times as they wished to advance their learning or clarify any issue they had in the forums, depending on their own knowledge and skills. Ostashewski et al. (2011) describe this flexible access to the online course as a benefit of online learning. Mastering individual units before continuing on to the next level enabled the students to learn at their own pace (Chou & Liu, 2005).

Most of the students in this study, apart from Frank, had trouble interacting in the forums, the quiz attempts were marginal and they did not use their e-portfolios for reflection or showcasing their learning despite being told the benefits (Research Journal, 7/8/13). Val (Interview 1, 8/11/13), from School B, believed that the students needed to be taught how to reflect on their work. Gaye (Interview 1, 21/11/13) and Jason (Interview 1, 19/11/14), also from School B, said the students needed to be taught to engage with Web 2.0 tool from Y9 or prior to using it in a learning topic. Ryan (Interview 2, 25/10/13), one of the participant students, commented in his interview that Facebook would have been a lot easier as most students knew it well. The researcher reasons that this demonstrates why prior-learning of online tools makes content learning easier for the students as discussed in Section 4.3.2. Gaye (Interview 1, 21/11/13) also said in her interview that "teaching students how to use MyPortfolio and forums beforehand ensured that they can enjoy the robotics course more, rather than getting despondent because they can't do something or find it difficult to do".

5.3.2. Conation

Whilst access to the online course, background knowledge and skills of electronics and Web 2.0 tools, and interaction with the online course can be identified as external drivers to student engagement, conation becomes the key to students' own internal motivation for completing a course. Often the effort to complete a task may seem too difficult and many students give up before they achieve success. For example Ryan frequently postponed tasks until it was too late to successfully complete the assessment.

To develop and improve knowledge and skills, a certain amount of persistent effort is required to ensure student engagement. Student engagement requires concentrated attention, interest in the subject matter and enjoyment when completing the activities (Shernoff et al., 2003). Persistent or consistent effort may mean students find it difficult to get started but continue until the task is completed, gaining worthwhile rewards, however, many students may give up before they achieve success suggesting they lack conation or internal drive. "**No pain, no gain** is an exercise motto that promises greater value rewards for the price of hard and even painful work." (Wikipedia, 2014). Using this sport analogy to training in academic work suggest that anything worthwhile may mean effort that is not always pleasurable at the time. This effort was illustrated by Frank who completed all the pre-activities learning to program the robot and then spent most of his holiday collaborating with the researcher on the forum to ensure his robot functions correctly. This ensured that he eventually completed the assessment with an 'excellence' grade.

Many educational studies seem to focus more on the outside drivers that influence student engagement but this study shows that it may not always be possible for teachers to overcome negative student conation. Chang (1999) evaluates the students' feelings about learning, the teacher, peers and technology to determine motivation but these are all external drivers and seem to take the students' responsibility away. According to Covey (1992), people have a choice between stimuli from our environment and our response to that stimuli. His proactive model, shown in Figure 5.2, identifies a person's freedom to choose appropriate responses to a stimulus. This freedom to choose means that even if there is a positive stimulus, a positive result is not guaranteed and vice versa. This means that there may be times that whatever the teacher does to motivate and encourage student engagement; a successful result may not always be possible, if students choose not to be engaged. Data from this

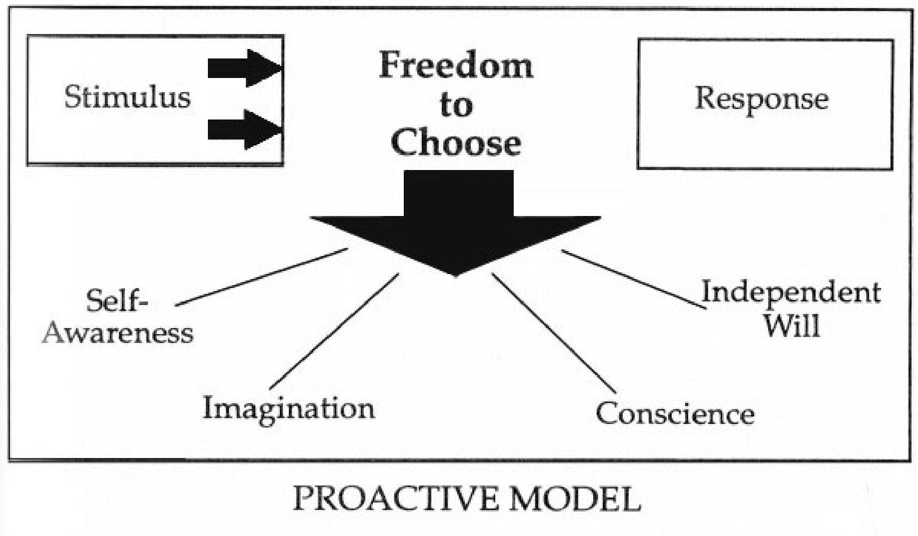


Figure 5.2 Covey's Proactive Model (Covey, 1992)

study suggests that students own the responsibility of successful learning outcomes in conjunction with their teacher, peers and the technology. For example, one of the main issues in this study was the participant students’ motivation to complete the Electronics subject. Only one of the students was motivated to complete the subject and did so successfully. Data from the study suggested that most of the others felt they did not need the credits to pass Level 3 NCEA, as they have already been accepted at their next endeavour in the subsequent year.

Interestingly, Jones and Issroff (2006) describe two types of motivation, authentic and inauthentic, both which were found in this study. Authentic motivation is when the learner is interested in the development of long-term knowledge whereas inauthentic motivation is when the focus is on assessments and the tactics of schooling. Most of the participant students had demonstrated inauthentic motivation as they were only interested in completing the assessment tasks, as described in Section 4.5.2, and they did not complete most of the pre-activities learning to program the robot. Stark and Woollard (2011) suggest that focusing on assessment criteria results in short-term memorising that only motivates students to “play the system” (surface learning). Frank, on the other hand took ownership of the learning problem and focused on long term understanding of ideas, developing critical thinking to help with construction of new knowledge and skills thus demonstrating authentic motivation . This concept of deep learning ensured that he was able to complete the assessment successfully by finishing all learning tasks.

5.3.3. Key competencies

For many students there is a fine line between consequences and rewards, especially inauthentically motivated students involved in "surface learning" as described by Stark and Woollard (2011). Unfortunately, or fortunately for them, the consequences in the high school environment may be inconsequential in the short term. However, this approach in real life may have different consequences. The NZC identifies key competencies people need to be successful in society and advocates that young people should be confident, connected, actively involved and lifelong learners (Ministry of Education, 2007). These competencies are developed continuously throughout our lives and the expectation is that by the time students leave school they have the confidence to successfully integrate into society. Throughout their school years teachers, parents and whānau provide guidance to help students develop these competencies.

Of the five key competencies, thinking, using language, symbols and text, and managing self, are the main competencies to be successful learning robotics online. In this study, the students needed to be "creative, critical, and use metacognitive process to make sense of information, experiences and ideas" (Ministry of Education, 2007, p. 12) to create new robot designs and programs for the assigned task. They also needed to learn to use language, symbols and text specifically to do with the type of robots they used and they needed to be able to managing themselves, to ensure they completed online activities. Unfortunately, many students seemed to have difficulty working successfully independently in an online environment and in class, indicating a low level of conation. The study showed that self-management was probably the biggest problem for these students. Their reluctance to use class time effectively and procrastination were identified as issues by the researcher as students continually postponed assigned activities (As discussed in Section 4.5.2). The teachers from School B believed students needed to be taught self-management and online skills, including online behaviour and Web 2.0 skills. The students' successful use of these skills is dependent on teacher expectations and school and class culture (McGee & Fraser, 2012). Students are more successful if they came through an educational system where they were taught key competencies and digital literacy skills at every year level, advancing their skills to ensure they are able to use these skills for their learning. Teaching students online skills and using other e-learning strategies "can contribute directly to the development of these key competencies" (Ministry of Education, 2006, p. 8).

5.4 Implementation

Course implementation is another part of the complex puzzle to facilitate student engagement. Considering course design, the students and how a course is executed are all factors to be taken into account to improve the occurrences of student learning. This section discusses the influence of reliable access to the online course, students' interaction with the online course and the influence of learning culture and the role of the teacher during course implementation.

5.4.1. Reliable Access to the Online Course

Reliable access to the online course had a fundamental influence on students' ability to benefit from the learning material and was a critical component to achieving student engagement and learning. That means the technical tools used must be up-to-date, reliable and easy to use and students must be able to access the online tools effortlessly (Garrison & Kanuka, 2004). Barriers to reliable access prevented students from being engaged in the online course and advance their learning. This was exemplified by the influence of the slow wireless Internet connection speed in the classroom, on the students' engagement while in class (As discussed in Section 4.2.1). Sun et al. (2008) and Chang (1999) also identified access as one of the key areas when measuring the effectiveness of an online course. Although Chang (1999) also included the students' feeling about the amount of work in the access area, this study only focused on physical aspects of access to the Internet and the Web, the frequency of students' access and the issue of laptop security. This section discusses how reliable access to an online course can positively influence student ability to complete learning outcomes and their engagement in the course.

In this study, slow Internet connection speed and outdated computer hardware influenced the students' ability to positively interact with the online course. This was illustrated by the difficulty the students had when accessing the Web in the classroom using the wireless hub as exemplified by Ryan's comments below. There were many times in the data collection period when the participant students were unable to access the online course in class or the response time accessing the online environment was slow. This issue was illustrated with Ryan's (Interview 2, 25/10/13) comments "school computers are crap", "Internet access is horrible" and "probably lost half a year logging on". Although students were able to bring their own devices many were reluctant for security reasons as described in Section 4.2.4. The participant students also became reluctant to use the online environment in class because of the reason stated above. Sun et al. (2008) also determined that technology with a slow response time discourages students from using online courses. Most people when interacting online want immediate feedback on their actions.

Another key aspect was the ease with which the students could access the wider online environment beyond their course site. The data from this study concurs with the literature in that students want to experience easy access to the Web and feel in control of their learning (Chang, 1999; Garrison & Kanuka, 2004; Sun et al., 2008). In this study both the researcher and the participant students experienced frustration logging onto the Web and registering to the MyPortfolio site (As discussed in Section 4.2.2). The Web needs to be accessible when and where the students want to access it. Multiple logins were required on the school network to access the web browser, the e-mail account, Moodle and MyPortfolio. Registering to the MyPortfolio site required manual permission approval which took up to five days for the students to receive an e-mail, with 24 hours to accept. If this was not done in the allotted time, the requests expired and had to be repeated. This was extremely frustrating for both students and researcher and the researcher believe it could be one of the reasons the participant students never used e-portfolios.

Both Shaun (Interview 2, 18/10/13) and Chris (Interview 2, 30/10/14) stated that they felt online learning provided the option to work at home as students had more time there. Frank (Interview 2, 30/10/13) concurred with this by stating “there are no interruptions at home”. Regular access to the online course was another key component that influenced student engagement and assisted progress made on learning outcomes. According to Lynch (2004) and Wright (2010), students make progress with regular access to online tools and by actively participating. In this study, the students’ irregular class attendance (As discussed in Section 4.2.3) did not help ongoing engagement in class, however, Frank seized the opportunity to use the online environment continually at home. He was able to improve his knowledge and skills through content exploring, completing practical activities (he had a robot at home) and online collaborations to complete the course with an ‘excellence’ grade.

5.4.2. Interaction with the Online Course

Interactivity was a key indicator of student engagement in this study. Whilst access to the online course and background knowledge and skills influenced student engagement, it was when the student’s individual interactions were evaluated that true engagement was determined. Evidence of interaction demonstrates effectiveness of that engagement on learning and how motivated the students are to complete the course (Lynch, 2004). Like Pachler and Daly (2011) found, the participant students were able to construct new knowledge through interaction with the online content, using forums and attempting quizzes. This was illustrated by Frank’s successful interaction with the online course and subsequent completion of the assessment. He actively completed the online activities and engaged in online forum discussions with the researcher to improve his understanding of the hardware and software content, to enable him to create new robot software programs. Students were able to use a variety of different visual activities which they could re-watch or repeat if they wished to. According to Lynch interactivity is one of the key areas to address to improve the usefulness of the online course (2004).

An online robotics course can provide a positive outcome for students when it provides interactions that are purposive, simplistic and immediate. Students need targeted learning outcomes to give them purpose or good reason to complete a task. For example, they will read information if they need it to complete a task (Jason, Interview 1, 19/11/13) whilst normally students do not like to read (Gaye, Interview 1, 21/11/14; Jason, Interview 1, 19/11/13; Val, Interview 1, 8/11/13). In this study, the participant students were given the learning outcomes in each section of the robotics online course so that they knew what they needed to do for that section. Students also wanted online courses that are easy and simplistic. As Val (Interview 1, 8/11/13) said they have a “butterfly mentality” where they “flick, flick” through the information and if they are not engaged immediately they will move on. Simplicity indicates how easy it is to understand the online course. Students must have the literacy skills to understand and comprehend what the content is about. In this study, the perceptions of the participant students on the simplicity of this course varied considerably. Whilst Chris (Interview 2, 30/10/13) felt it was easy, the amount of reading was acceptable and it was easy to find information, Ryan (Interview 2, 25/10/13) felt there were too much information and it was confusing. Although the students were given the opportunity to provide feedback, throughout the course period, it was only James who had provided constructive feedback for improvement in the simplicity of this course (Researcher Journal, 9/9/13). Immediacy is a concept closely linked with reliable access to the online course and allude to by Sun et al. (2008) because technology with a slow response time will discourage students from using the online environment. This concept goes further with students who want immediate feedback on progress for example using formative quizzes in Moodle as used in this study. Gaye also suggested that students who get positive results in quizzes are motivated to continue. This includes having easy online quizzes at the start for students to receive early rewards (Gaye, Interview 1, 21/11/14).

Using Forums, MyPortfolio and other Web 2.0 tools enables the students to present their learning, in their own words and constructively reflect on their own and other students’ performances (Chambers et al., 2007). They may present this using text or videos which broaden the opportunities students have to communicate rich data. Online collaboration allows students to develop their understanding of their course content and is an important aspect of Technology Education (Fox-Turnbull, 2010) and product development. Only one participant student, Frank, actively interacted in the forums to develop his own learning. There were, however, some good examples from Gaye (Interview 1, 21/11/13), of students who used Wikis and e-portfolios effectively to showcase their learning. Gaye also used other Web 2.0 tools like Skype, Voki and Tagxedo to engage diverse students and progress their learning. Shaun (Interview 2, 18/10/13) indicated that using Moodle for the online course made access to the course content easier as all the information is in one place. Collaborating online through forums provide students with opportunities to develop their knowledge and skills of the topic through cognitive and experiential means (Fox-Turnbull, 2010) which improve overall student satisfaction (Palmer & Holt, 2012) as illustrated by Frank when he successfully completed the course.

There are various features which support assessments in online courses such as quizzes, e-portfolios, forums and Google Docs. Although the participant students in this study did not use the online opportunities for assessments, they were able to use quizzes formatively and forums for knowledge building and idea collaboration to develop their understanding of the Achievement Standards they attempted. Val (Interview 1, 8/11/13) and Gaye (Interview 1, 21/11/14), the teachers from School B, had used quizzes, forums and e-portfolios or Wikis, to grade student achievement. Using Web 2.0 tools in the online robotics course can provide students with opportunities to document their projects, including planning, design and reflection (Chambers et al., 2007) as a framework for authentic technological learning (Fox-Turnbull, 2003). Unfortunately, the participant students did not use this opportunity as illustrated by the students not using their e-portfolios or a lack of student conation as illustrated by the students’ work ethics and attitudes towards learning and assessments.

5.4.3. Learning Culture and the Teacher

The school and classroom learning culture and the teacher’s approach to teaching and learning had a direct influence on student engagement. The impact of the learning culture was observed through the students’ work ethics and attitudes towards learning and assessments, their behaviour towards each other, school property and homework, and their attitudes towards using digital technologies. This was illustrated by the students continually postponing tasks and assessments, the students’ treatment of Frank, the students’ respect for school property, only Frank working at home and the culture of not using school e-mails. Although the school culture influenced the classroom culture and teacher attitudes, it is the classroom teacher, using his/her own values, beliefs and philosophy of learning, who is largely responsible for developing a positive classroom culture with the support of the students. Successful teachers have a positive impact on student learning (McGee & Fraser, 2012) which improves overall engagement in the course.

The researcher designed the online robotics course based on recommendations outlined in the literature on the NZC (Ministry of Education, 2007) and the approach that provides successful outcomes for Technology Education. Unfortunately, it seemed that the classroom culture of the participant students suggested a different philosophy and students did not have the developmental period to be enculturated to the requirements of the NZC. Whilst the participant students relied heavily on Mrs Brown for content guidance and problem solving, the researcher expected them to be more independent, self- directed learners as the content of the robotics course required the students to be thoughtful and creative problem solvers. The recent philosophical changes in Technology Education (Harwood & Compton, 2007) also influenced the way the researcher, in her role as classroom teacher, taught technology. The issue in this study appeared to be that the initial classroom teacher, and the Technology department at School A, had not taken that philosophical shift. Combining traditional ways of teaching technology with modern technologies, such as robotics, does not facilitate Technology Education as required by the NZC (Ministry of Education, 2007).

The NZC (Ministry of Education, 2007) outlines key competencies students should have to be successful in society and online learning facilitates that (Ministry of Education, 2006). The schools' expectation of students was clearly stated in Ryan's (Interview 2, 25/10/13) comment in his end-of-course interview that "in most technologies if you have a problem the teacher sorts it out for you". This is not the intent of the NZC. The role of the teacher at this level of the NZC (Level 8 of the Technology learning area) is to encourage and support the students to be independent and creative problem solvers. Teaching basic skills are only part of it. Although, direct support and guidance from the teacher may be required at times and in the beginning of the students' schooling, there must be a gradual increase in learner control through the use of ICT practices (Zaka, 2012). Consequently, by Y13, the teacher should facilitate learning and teaching, guide the students and provide encouragement when needed (Harwood & Compton, 2007). This contrast in learning styles, whilst students found it difficult, highlighted a key aspect of teaching that has to be taken into account when developing online courses. The alignment of philosophies and expectations between the teacher, the students and the online course is critical to ensure student engagement. The online robotics course was designed to be exciting and had the potential to engage but the mismatch in teaching philosophies seemed to be a reason why students had difficulty in successfully completing the course.

The teachers from School B thought that a blended learning course in robotics would benefit students the most if they still had to develop the key competencies. They believed this requires teacher guidance to learn effectively. In this study, the students had to be reminded continuously to interact in the online course and complete activities. Frank also said he learned the most in a blended environment because “online there are no interruptions and in class you can get the teacher’s opinion”. The teachers from School B also believed many students were reluctant to read which meant teacher guidance was important. Gaye believed the effectiveness of the online course in the blended classroom also depended on the teacher’s willingness to actively use the online component in the classroom environment.

This study also showed that the online robotics course had benefits for the teacher. Using an online course freed up teacher time to focus on emergent needs in the classroom and strengthening personalised learning, for example, while the teacher provide one-to-support, the more competent student can move ahead or attempt more complex tasks. This was illustrated by the researcher helping Ryan in class, to show him how to execute the activities, while Frank was able to complete the activities and mainly interact online when he had a problem. The implemented online course structure also supported teachers with limited experience of the topic and made lesson planning easier (Gaye, Interview 1, 21/11/14; Val, Interview 1, 8/11/13). Using online tools to evaluate and grade performance makes it easier for the teacher as all the information is in one place like assignment drop boxes, e-portfolios, quizzes or forum interactions. This was illustrated by the feedback the researcher gave John on the assignment drop box for his draft report. About six weeks later he asked for feedback and the researcher referred him back to the drop box. Gaye and Val used e-portfolios, forums and quizzes successfully for students’ grades.

5.5 Chapter Conclusion

This chapter discussed the findings of this study focusing on three aspects, the course design, student consideration and the implementations of the online robotics course in a blended environment. This chapter evaluated the importance of course design in a technical subject and how Web 2.0 tools can successfully be used for project-based learning. The students’ readiness to engage in an online course is outlined by discussing the students’ background knowledge and skills in electronics and Web 2.0 tools, their conation and their key competencies. Finally, the implementation of the course is discussed by explaining the influence of reliable access to the online course, the students’ interaction with the online course and the influence of learning culture and the role of the teacher in a blended environment. Chapter 6 will conclude with a summary of answers to the research questions, recommendations for practice and implications for future research.

Chapter 6: Conclusion and Recommendations

6.1 Conclusions

This thesis presents an action research (AR) study on the use of an online robotics course in a senior secondary school class. The use of the online course, and other Web 2.0 tools, in a blended environment has been investigated to determine how the teacher and students used it to achieve teaching and learning goals. The main research question was: *How can an online course be used by classroom teachers, to teach a course in robotics in the senior secondary school?*

Data was gathered through classroom observations, online interactions with the students and semi-structured and in-class interviews with teachers and students. Although the intention was to use online reflections, due to the reasons discussed in previous chapters, this did not happen. Even with the best intentions and planning, what happens in practice is not always what is expected, especially in education. This is probably one reason why AR is so well suited for researching teaching practice because it enables teachers to reflect on and improve their teaching practice in a controlled setting (Cohen et al., 2011). The progress in teaching practise does not always occur within one student group. Many times teachers may learn from one class of students and change and improve their practice in the next class. AR is more than improving learning outcomes for a specific class but also developing teacher's long-term professional practice (Hine, 2013). When this researcher started the data gathering phase of her research, she had made assumptions about the students and the school context which made the execution of the online course challenging. The study found many factors that influenced student learning such as reliable access to the online course, the students' background knowledge and skills, student conation and dispositions, and the learning culture of the teacher and the school.

Although, there were many challenges in this study the researcher still believes that using robotics as a Technology subject provides opportunities for students to develop technical and conceptual knowledge (Jones, Buntting, & de Vries, 2011) in a constructionist learning environment (Ostashewski et al., 2011). With robotics, students are able to construct new knowledge and develop their thinking skills through programming and design concepts (Chambers et al., 2007). Using an online course component to teach robotics provides students with additional benefits through development of 21st Century skills. Alemdar (2011), Burbaite, Stuikys, and Marcinkevicius (2012), and others state that students will be intrinsically motivated to do robotics, however, student motivation in this study rebuts this. Despite the motivational issues the students had, this study suggests using robotics as the theme, or teaching robotics using an online course, is still beneficial for a range of reasons such as development of critical thinking and 21st Century skills. The experiences of the teachers at School B supported the value of the online robotics course.

Technology is about developing products and systems and technology practice is an important part of this process to ensure quality outcomes (Ministry of Education, 2007). Using the online environment and Web 2.0 tools can directly benefit the product development process using project management approaches for example, all the course and content information can be in a common learning area, Wikis or e-portfolios can be used for project documentation and collaborative work, and forums can provide opportunities for idea collaboration and discussion in authentic ways to help students work through their product design process (Chambers et al., 2007; Fox-Turnbull, 2003; Woo et al., 2011).

To answer the main research question the following sub questions are addressed:

- *How can an online robotics course adequately address and advance student learning outcomes? How is student achievement measured?*

  This online robotics course provided students with opportunities to re-watch or re-do a variety of activities anytime and anyplace to strengthen their understanding of a topic. Various modular learning objects can cater for diversity of learning styles and abilities where students can learn at their own pace, choose their own sequence of activities and also choose the content to access (Chou & Liu, 2005). Students in control of their own learning seem to be more engaged in the course content (Shernoff et al., 2003). Although students prefer working at their own pace, a high degree of self-management (one of the key competencies students needed be successful in society) was required (Tallent-Runnels et al., 2006).

  The literature review and teachers from School B showed that teaching students using an online course, with the elements outlined below, can directly contribute to the development of these key competencies (Ministry of Education, 2006). These elements are the inclusion of opportunities for students to think and reflect, learn through practical experiences and activities, learn through conversation and interaction, whilst ensuring that the students' background knowledge and skills are also considered. This study also shows that pre-learning of Web 2.0 skills will be advantageous to ensure students concentrate on developing knowledge and skills about the course content.

Student achievement in a robotics course can be measured in various ways such as online quizzes for formative assessments and e-portfolios or Wikis can be used to reflect on course work and present project reports for formative and summative assessments. Forum interactions can be used to authenticate student work throughout the course period.

- *What aspects of on-line course design are successful for teaching robotics?*

There were a number of aspects or features of the on-line course design used in this study that fostered successful teaching of robotics such as the structured modules that included content and activities, social collaboration through forums and supporting learner-centeredness which makes individual classroom sessions easier. The teachers from School B believed that one of the main advantages of the online course in robotics was to support the classroom teacher with content and structure, especially if the classroom teacher did not have any prior knowledge in teaching robotics. The structured approach and integrated course plan saved time in teacher preparation and embedding the curriculum document as part of the online course meant it became a living document teachers updated regularly. Using online tools for assessment purposes also made grading easier and placed all the assessment information centrally.

The researcher also found that the structured online robotics course which used hyperlinks and was easy for students to use also freed up teacher time to focus on emergent needs in the classroom and strengthen personalised learning. This was also mentioned by the teachers from School B. The learner-centred approach meant the students could work at their pace, anywhere and anytime, and while the researcher provided one-to-one support in class, others were able to raise questions in the forums that can be answered outside class before the next period. This approached was used when Frank and James used the online forums whilst the researcher was able to work with the other students in class. This was especially valuable when fault finding the students' robot programs as it was not always easy to have focused time in the class for the researcher to debug their programs and/or provide guidance.

- *What types of online learning experiences provide a positive outcome for students?*

Students want online learning experiences that are purposive, simplistic and immediate. Val, one of the teachers from School B, used the butterfly metaphor to describe how the students “flick, flick” through information and if they do not find information quickly they lose interest and move on. This means the online course must have meaningful and easy interactions to ensure students learn. Replacing text with videos, podcast and simulations to teach concepts may be more beneficial to today's students. Using well-organised, structured navigational hyperlinks to ensure information is accessible will make the course site less confusing.

In this study, the potential existed for students to use online forums to develop critical thinking through targeted questions and engagement in questions and answers about the project to clarify and develop knowledge and skills. The researcher found students learnt to better articulate their problem when they had to write it down. Only Frank was able to use the forums successfully to develop his understanding of the robot system. Being able to help students online can be easier in a robotics and programming environment because the teacher has more time to determine or analyse the students' problem. The students also used quizzes as a formative assessment tool and although these were not used for grades it did, however, show the students' level of engagement. Wikis, e-portfolios and Skype were not used by the participant students. Gaye, from School B, however, had used these. Wikis and e-portfolios were successfully used by Gaye's Y10 class to reflect on their robotics project and Skype was used to contact the researcher (which could have been any robotics specialist) at home to ask questions.

6.2 Recommendation for teaching practise

Findings from this study, as discussed in Chapter 5, showed that there are benefits in using online course sites for robotics. The research was done in one school, with some recommendations from the additional teachers from another school. Key literature was presented that support the findings. This study showed that there are two areas that need to be considered to ensure successful integration of an online robotics course into the classroom (i.e. blended environment). A school-wide programme that encourages blended classroom practices needs to address the reliability of the network infrastructure and hardware, the teacher and school learning culture and the students' key competencies to ensure students benefit from an online course in robotics. Furthermore, teacher professional development needs to address the changing philosophies of Technology Education, robotics as a teaching tool, online learning tools and teaching of key competencies. Overall, it is important that all stakeholders, including school leadership, classroom teachers, the school community and other professional organisations linked to the school, support teachers and encourage them to use blended learning (Zaka, 2012).

6.2.1.School Programmes

Zaka (2012) recommends a gradual student transition, from traditional to independent learning, mainly due to the difficulty students have in managing their own learning. Most students seem to have a low readiness to learn in a blended environment. This relates to the difficulty students have in using digital devices for educational purposes (Wright, 2010). All the teachers interviewed, including Mrs Brown at School A, encourage learning programmes teaching key competencies and digital literacy from Y9. This means the students can progress at every year level, advancing these skills to ensure they can use them for learning. A successful implementation of this programme will depend on reliable network infrastructure and hardware and a school-wide learning culture that support the development of these key competencies.

For an online course to address and advance student learning, access to the course needs to be reliable and available when and where the students want to access it. In this study, it was evident that reliable access to the online robotics course was very important. To ensure student engagement and learning, technology hardware and systems must be up-to-date, reliable and easy to use (Garrison & Kanuka, 2004) and available to the students both at school and at home. It is also important the students regularly access the online course and complete activities to make progress. Reliable access to the online course can also influence the learning culture as equipment available to students is one of the parameters influencing school culture (Ministry of Education, 2014a). As Sun et al. (2008) determined, technology with a slow response time will discourage students from using the online course. With school leadership support, having reliable network infrastructure and hardware in place, the next step is to ensure the teachers' approach to teaching and learning positively impact on the learning culture and promotion of student engagement. This study found there are still gaps between the teacher's philosophies of Technology Education and the intent of the NZC. Furthermore, the benefits of a robotics curriculum have been outlined, but many teachers do not have experience teaching the subject. Therefore, including school programmes from Y9 to teach key competencies and digital literacy, especially in the Technology learning area, will also require teacher professional development.

6.2.2.Teacher Professional Development

In this study, one of the key findings was the importance of teachers' philosophy of teaching when teaching robotics online as discussed in section 5.4.3. As a course designer, this needs to be taken into account. The NZC outlines the vision for 21st Century learners and underpins the philosophy of Technology Education. The importance of key competencies and using sociocultural and constructivist learning approaches in Technology Education have been discussed in previous chapters. Teacher pedagogy needs to be aligned with the requirements for 21st Century learning and the philosophy of Technology Education to ensure student achievement and learning.

Zaka (2012) recommends using both in-school professional development (PD) and support, by encouraging teachers to share blended teaching knowledge and practices, and also engaging in out-of-school PD to further increase teachers abilities, and collaborating with other schools. There are not many schools that teach robotics, or other technology subjects online and the researcher identified only two papers describing the teaching of robotics online for teacher PD. Alemdar (2011) and Ostashewski et al. (2011) outline online courses they used to teach teachers how to incorporate Lego Mindstorms robotics in their classrooms. Robotics is identified as an effective method for teaching STEM (Science, Technology, Engineering, Maths) education but teachers do not always have the skills to effectively integrate it (Alemdar, 2011). Teaching teachers online provides them with flexible access to online resources, the ability to experience authentic learning through social networking and effective learning of the content (Ostashewski et al., 2011) which they can apply in their own classroom programs to promote student engagement. Creating online PD courses for teachers by robotics specialists who understand the philosophy behind Technology Education can provide access to quality resources to a wider audience, and include experiences and skills development with online learning tools and teaching key competencies.

6.3 Implications for Future Research

Despite the rapid growth of online and blended learning, various researchers noted that there is not enough research into online learning and blended learning and its effectiveness (Jaggars & Bailey, 2010; Langenhorst, 2011; Zaka, 2012). This literature review also acknowledges the fact that there is very little research on the use of online courses to support the teaching of robotics, especially as part of Technology Education in secondary schools. Although this study raised some recommendations for practice, a number of other issues indicate potential areas for future research.

6.3.1. Conation

Conation was one of the main reasons identified in this study that influenced student engagement. Most of the Y13 students had difficulty focusing on the required tasks, although it was argued that robotics should be intrinsically motivating, only one student worked efficiently. The researcher discussed in section 5.3.2 the fact that most research focus on what teachers should do to motivate students but this study showed that sometimes, it does not matter what teachers, the school or parents/caregivers do to encourage students, they may decide not to be engaged. Future research could explore reasons for this, for example: “What is the role of NCEA in motivating students to complete courses if they have enough credits for their next endeavour? “ This may especially be true in the last year of school. This will also link into the effect at Y13 if students went through a pipeline from Y9 where they learned key competencies and digital literacy. Would that make a difference?

6.3.2. Development of Critical Thinking Skills through Forums

This study showed the importance of reliable network infrastructure and hardware for student engagement, a factor which has been verified by others (Akyol & Garrison, 2010; Chang, 1999; Garrison & Kanuka, 2004; Sun et al., 2008; Zaka, 2012). When that is in place, the important concept is student learning and the development of their critical thinking skills. Many researchers found that using online or blended courses enable students to develop independent learning skills, improve self-management and higher order thinking skills (Ministry of Education, 2006; Zaka, 2012). Lunney et al. (2008) even suggest that better results can be achieved than in the traditional classroom. Critical thinking skills is a vital component of successful product development but how effective the development of these skills is in an online or blended environment using forums, especially in robotics, still need more consideration.

6.3.3. Alignment of Philosophies

Finally, teachers involved in Technology Educations need to ensure matching philosophies with the intent of the NZC. As discussed in section 6.2.2 online robotics courses for teacher PD using the philosophy of Technology Education can address some of the issues around mismatch teaching philosophies as found in this study. For this to occur, more evidence especially in a New Zealand context is needed.

6.4 Chapter Conclusion

This chapter concluded the thesis by summarising the research approach, justifying the use of robotics as a Technology subject even with the challenges throughout the data gathering period and answering the research questions. The answers to the research questions include how an online course can address and advanced student learning outcomes, the aspects of the online course design that support the teaching of robotics and the types of learning experiences that provide positive outcomes for students. This chapter also provide recommendations for teaching practice by using school programmes that support online learning and teacher PD in Technology Education philosophies, 21st Century learning and robotics. Targeted school programmes and teacher PD should promote student engagement and learning. Finally, implications for further research in student conation, development of critical thinking skills and alignment of teacher philosophies to Technology Education have been provided.

References

Akyol, Z., & Garrison, D. R. (2010). Understanding cognitive presence in an online and blended community of inquiry: Assessing outcomes and processes for deep approaches to learning. *British Journal of Educational Technology, 42*(2), 233-250.

Alemdar, M. (2011). AC 2011-1909:Introducing k-12 teachers to Lego Mindstorm robotics through a collaborative online professional development course. *American Society for Engineering Education*.

Anderson, H. (2009). Formative assessment: Evaluating the effectiveness of on-line quizzes in a core business finance course. *Massey U. College of Business Research Paper No. 2, 13*(1), 26-40.

Anderson, T., Liam, R., Garrison, D. R., & Archer, W. (2001). Assessing teacher presence in a computer conferencing context. *Asynchronous Learning Network*.

Baran, E., Correia, A. P., & Thompson, A. (2011). Transforming online teaching practice: critical analysis of the literature on the roles and competencies of online teachers. *Distance Education, 32*(3), 421-439.

Baron, P., & McLaren, E. (2006). *Overcoming skill shortages: employer perspectives and strategies*: Labour Market Dynamics Research Programme, Massey University.

Becker, H. A. (2001). Social impact assessment. *European Journal of Operational Research, 128*(2), 311-321.

Beetham, H., & Sharpe, R. (Eds.). (2007). *Rethinking Pedagogy for a Digital Age. Designing and delivering e-learning*. USA and Canada: Routledge.

Bellanca, J. A., & Brandt, R. S. (2010). *21st century skills: Rethinking how students learn* (Vol. 20): Solution Tree Press Bloomington, IN.

Blocher, J. M., de Montes, L. S., Willis, E. M., & Tucker, G. (2002). Online learning: examining the successful student profile. *Journal of Interactive Online Learning, 1*(2), 1-12.

Bogdan, R., & Biklen, S. (2007). *Qualitative research for education: An introduction to theory and methods*. Boston: Pearson Education.

Burbaite, R., Stuikys, V., & Marcinkevicius, R. (2012). The LEGO NXT Robot-based e-Learning Environment to Teach Computer Science Topics. *Electronics and Electrical Engineering, 18*(9), 113-116.

Carmichael, E., & Farrell, H. (2012). Evaluation of the effectiveness of online resources in developing student critical thinking: Review of literature and case study of a critical thinking online site. [Literature review and case study]. *Journal of University Teaching & Learning Practice, 9*(1), 4.

Carrol, N., & Burke, M. (2011). Learning effectiveness using different teaching modalities. *American Journal of Business Education (AJBE), 3*(12).

Chambers, J. M., Carbonaro, M., & Rex, M. (2007). Scaffolding knowledge construction through robotic technology: A middle school case study. *Electronic Journal for the Integration of Technology in Education, 6*, 55-70.

Chandra, V., & Chalmers, C. (2010). Blogs, wikis and podcasts: collaborative knowledge building tools in a design and technology course. *Journal of Learning Design, 3*(2), 35-49.

Chandra, V., & Fisher, D. L. (2009). Students' perceptions of a blended web-based learning environment. *Learning Environments Research, 12*(1), 31-44.

Chang, V. (1999). *Evaluating the effectiveness of online learning using a new web based learning instrument.* Paper presented at the Western Australian Institute for Educational Research Forum.

Chou, S. W., & Liu, C. H. (2005). Learning effectiveness in a Web-based virtual learning environment: a learner control perspective. *Journal of Computer Assisted Learning, 21*(1), 65-76.

Clark, L., Nute, H. D., & Zellerer, E. (2001). *Applying Complex Pattern Analysis to Reduce Violence in the School Environment*. Paper presented at the International Conference on Violence in Schools and Public Places, Paris, France. http://www.criminology.fsu.edu/faculty/clark/schoolviolence.html

Clarke, S. (2005). *Formative assessment in the secondary classroom*: Hodder Education

Cohen, L., Manion, L., & Morrison, K. (2011). *Research Methods in Education* (7 ed.). London: Routledge.

Cole, M. (2009). Using Wiki technology to support student engagement: Lessons from the trenches. *Computers & Education, 52*(1), 141-146.

Conole, G., Oliver, M., Falconer, I., Littlejohn, A., Harvey, J., & Conole, G. (2007). Designing for learning. *Contemporary perspectives in e-learning research: themes, methods and impact on practice', part of the Open and Distance Learning Series, F. Lockwood,(ed), RoutledgeFalmer.*

Cook, J., White, S., Sharples, M., Sclater, N., & Davis, H. (2006). *The Design of Learning Technologies*: Routledge.

Covey, S. R. (1992). *The Seven Habits of Highly Effective: Powerful lessons in personal change*. London: Simon and Schuster Ltd.

Craig, D. V. (2009). *Action research essentials* (Vol. 11): John Wiley & Sons.

Creswell, J. W. (2012). *Educational research: Planning, conducting and evaluating, quantitative and qualitative research*: Pearson Education.

Davidson, C., Tolich, M., & Zealand, P. E. N. (1999). *Social science research in New Zealand: Many paths to understanding*: Longman.

de Vries, M. J. (2005). *Teaching about technology: An introduction to the philosophy of technology for non-philosophers* (Vol. 27): Springer.

Diaz, D. P., & Cartnal, R. B. (1999). Students' learning styles in two classes: Online distance learning and equivalent on-campus. *College teaching, 47*(4), 130-135.

Dyke, M., Conole, G., Ravenscroft, A., & de Freitas, S. (2007). Learning theory and its application to e-learning. *Contemporary Perspectives in E-Learning Research: Themes, Methods, and Impact on Practice*, 82-97.

Educational Research Human Ethics Committee. (n.d.). *Human Ethics* Retrieved March 13, 2013, from http://www.canterbury.ac.nz/humanethics/erhec

Fleischmann, K. R., Robbins, R. W., & Wallace, W. A. (2011). Information Ethics Education for a Multicultural World. *Journal of Information Systems Education, 22*(3), 191-201.

Fox-Turnbull, W. (2003). *The place of authentic technological practice and assessment in technology education.* (Master of Teaching and Learning), University of Canterbury, Christchurch, New Zealand.

Fox-Turnbull, W. (2010). The Role of Conversation in Technology Education. *Design and Technology Education: an International Journal, 15*(1).

Fox-Turnbull, W., & Snape, P. (2011). Technology teacher education through a constructivist approach. *Design and Technology Education: an International Journal, 16*(2).

Gardner, H. (2010). Five Minds of the Future. In J. Bellanca & R. Brandt (Eds.), *21st century skills: Rethinking how students learn*: Solution Tree Press Bloomington, IN.

Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education, 7*(2), 95-105.

Gilbert, J. (2005). Catching the knowledge wave. *The knowledge society and the future of education*.

Graham, C. R., & Dziuban, C. (2008). Blended learning environments. *Handbook of research on educational communications and technology*, 269-276.

Harwood, C., & Compton, V. (2007). *Moving from technical to technology education: Why it's so hard.* Paper presented at the TENZ Biennial Conference.

Hill, M. (2012, 20 May). Students flock to art despite job conditions, *The Press*. Retrieved from http://www.stuff.co.nz/national/education/6953301/Students-flock-to-arts-despite-job-conditions

Hine, G. S. (2013). The importance of action research in teacher education programs. *Issues in Educational Research, 23*(2), 151-163.

Hoepfl, M. C. (1997). Choosing qualitative research: A primer for technology education researchers. *Journal of Technology Education, 9*(1).

Holly, M. L., Arhar, J. M., & Kasten, W. C. (2009). *Action research for teachers: Traveling the yellow brick road*: Pearson/Merrill/Prentice Hall.

Hopkins, D. (2008). *A teacher's guide to classroom research*: McGraw-Hill International.

Innovative Experiment Co. Ltd. (n.d.). Inex Robotics. Retrieved 26 October, 2014, from http://www.inexglobal.com/

Jaggars, S. S., & Bailey, T. (2010). Effectiveness of fully online courses for college students: Response to a Department of Education meta-analysis. *New York, NY: Columbia University, Teachers College, Community College Research Center*.

Johnson, M. P., & Anderson, D. L. (2011). Using the internet to improve student learning and achievement: Approved masters' dissertation), University of Northern Michigan, Marquette, Michigan, United States of America. Retrieved from https://www. nmu. edu/sites/DrupalEducation/files/UserFiles/Files/Pre-Drupal/SiteSections/Students/GradPapers/Projects/Johnson_Matt_MP. pdf.

Jones, A., Buntting, C., & de Vries, M. J. (2011). The developing field of technology education: a review to look forward. *International Journal of Technology and Design Education*, 1-22.

Jones, A., & Issroff, K. (2006). Learning technologies:affective and social issues. In G. Conole & M. Oliver (Eds.), *Contemporary perspectives in e-learning research: Themes, methods and impact on practice*. New York: Routledge.

Kolikant, Y. B.-D. (2010). Digital natives, better learners? Students' beliefs about how the Internet influenced their ability to learn. *Computers in Human Behavior, 26*(6), 1384-1391.

Langenhorst, D. G. (2011). *Effectiveness of online instruction: Differences in measured student outcomes online versus face-to-face instruction at the high school level.* Northeastern University Boston.

Lego. (2011). Lego Education Curriculum Retrieved 8 September, 2012, from https://www.legoeducation.us/eng/curriculum/

Lei, C.-U., Krilavicius, T., Zhang, N., Wan, K., & Man, K. L. (2012). *Using Web 2.0 tools to enhance learning in higher education: A case study in technological education.* Paper presented at the Proceedings of the International MultiConference of Engineers and Computer Scientists.

Leung, H. (n.d.). Tagxedo. Retrieved 8 June, 2014, from http://www.tagxedo.com/

Lunney, M., Frederickson, K., Spark, A., & McDuffie, G. (2008). Facilitating Critical Thinking through Online Courses. *Journal of Asynchronous Learning Networks, 12*(3-4), 85.

Lynch, M. M. (2004). Learning online: a guide to sucess in the virtual classroom. London, UK: RoutledgeFalmer.

Mahara. (n.d.). Open Source ePortfolios. Retrieved 1 April, 2014, from https://mahara.org/

McGee, C., & Fraser, D. (2012). *The professional practice of teaching*: Cengage Learning.

McInnerney, J. M., & Roberts, T. S. (2004). Online learning: Social interaction and the creation of a sense of community. *Educational Technology & Society, 7*(3), 73-81.

McRae, J. (2005). Maori oral culture and literature(New Zealand), Routledge Encyclopedia of Post-Colonial Literatures in English, Second Edition

McTaggart, R. (1991). Principles for participatory action research. *Adult Education Quarterly, 41*(3), 168-187.

Merriam-Webster. (2014). Dictionary and Thesaurus, from http://www.merriam-webster.com/

Ministry of Education. (2006). *Enabling the 21st Century Learner: an e-Learning Action Plan for Schools 2006-2010*. Wellington: Learning Media Limited.

Ministry of Education. (2007). *The NZ Curriculum*. Wellington, New Zealand: Learning Media.

Ministry of Education. (2012a). *Achievement Standard 91638: Demonstrate understanding of complex concepts used in the design and construction of electronic environments*. NZQA. Retrieved from http://www.nzqa.govt.nz/framework/search/results.do?type=UNIT&query=91638.

Ministry of Education. (2012b). *Achievement Standard 91640: Implement complex techniques in constructing a specified complex electronic and embedded system*. NZQA. Retrieved from http://ncea.tki.org.nz/Resources-for-Internally-Assessed-Achievement-Standards/Technology/Level-3-Technology.

Ministry of Education. (2012c). *Achievement Standard Digital Technologies 91639: Implement complex interfacing procedures in a specified electronic environment*. NZQA. Retrieved from http://ncea.tki.org.nz/Resources-for-Internally-Assessed-Achievement-Standards/Technology/Level-3-Technology.

Ministry of Education. (2014a). Culture Retrieved 24 May, 2014, from http://www.educationalleaders.govt.nz/Culture

Ministry of Education. (2014b). What is our School Culture Like? – A Checklist for Analysing a School's Culture Retrieved 24 May 2014, 2014, from http://www.educationalleaders.govt.nz/Culture/Understanding-school-cultures/What-is-our-School-Culture-Like-A-Checklist-for-Analysing-a-School-s-Culture

Moodle Pty Ltd. (2014). Moodle. Retrieved 19 October, 2014, from https://moodle.org/

Moundridou, M., & Kalinoglou, A. (2008). Using LEGO Mindstorms as an instructional aid in technical and vocational secondary education: Experiences from an empirical case study. *Times of Convergence. Technologies Across Learning Contexts*, 312-321.

Mutch, C. (2005). Examining the ethical issues. *Doing educational research. A practitioner's guide to getting started.* (pp. 75-90). Wellington: NZCER.

Netsafe. (n.d.). Resources. Retrieved April, 16, 2013, from http://www.netsafe.org.nz/

Neuman, W. L. (2005). *Social research methods: Quantitative and qualitative approaches*. Boston: Allyn and Bacon.

New Zealand Qualification Authority. (n.d.). *Understanding NCEA.* Retrieved April, 7, 2013, from http://www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/understanding-ncea/

Norton, P., & Wiburg, K. M. (2003). *Teaching with Technology - Designing opportunities for learning* (Second ed.). Canada: Wadsworth/Thomson Learning.

Oddcast Inc. (2014). Create Speaking Avatars Retrieved 8 June, 2014, from http://www.voki.com/

Ostashewski, N. M., Reid, D., & Moisey, S. (2011). Applying constructionist principles to online teacher professional development. *The International Review of Research in Open and Distance Learning, 12*(6), 143-156.

Pachler, N., & Daly, C. (2011). *Key issues in e-learning: Research and practice*: Bloomsbury Publishing.

Palmer, S., & Holt, D. (2012). *Moving a unit online: a quantitative evaluation of student responses.* Paper presented at the ASCILITE 2007 : ICT : providing choices for learners and learning: 24th Annual Ascilite Conference, Nanyang Technological University, Singapore.

Parkes, S., Zaka, P., & Davis, N. (2011). The first blended or hybrid online course in a New Zealand secondary school: A case study. *Computers in New Zealand Schools: Learning, Teaching, Technology, 23*(1), 1-30.

Patton, M. (2002). *Qualitative research and evaluation methods*. Thousand Oaks CA, USA: Sage Publications.

Pearlman, B. (2010). Designing new learning environments to support 21st century skills. In J. Bellanca & R. Brandt (Eds.), *21st century skills: Rethinking how students learn* (pp. 116-147). Bloomington, USA: Solution Tree Press.

Picciano, A. G., & Steiner, R. V. (2008). Bringing the real world of science to children: A partnership of the American Museum of Natural History and the City University of New York. *Journal of Asynchronous Learning Networks, 12*(1), 1-16.

Prensky, M. (2001). Digital natives, digital immigrants part 1. *On the horizon, 9*(5), 1-6.

Pullar-Strecker, T. (2012, 4 August). Mapping our way on the e-learning highway, *The Press*. Retrieved from http://www.stuff.co.nz/technology/digital-living/7412699/Mapping-our-way-on-the-e-learning-highway

Scott, D., & Morrison, M. (2005). *Key ideas in educational research*: Continuum.

Seale, J., Boyle, T., Ingraham, B., Roberts, G., & McAvinia, C. (2006). Designing digital resources for learning. *Contemporary perspectives in e-learning research: Themes, methods and impact on practice*, 121.

Shernoff, D. J., Csikszentmihalyi, M., Shneider, B., & Shernoff, E. S. (2003). Student engagement in high school classrooms from the perspective of flow theory. *School Psychology Quarterly, 18*(2), 158.

Skype. (2014). Skype in the Classroom. Retrieved 16 June, 2014, from https://education.skype.com/

Snape, P., & Fox-Turnbull, W. (2011). Twenty-first century learning and technology education nexus. *Problems of Education in the 21st Century 34*, 149-161.

Stark, R., & Woollard, J. (2011). CAA 2011: Implementing e-portfolios in secondary schools: the lessons to be learned from higher education.

Stevens, K. (2011). Organizational, Pedagogical and Conceptual Changes in the Provision of Education in Rural New Zealand and Atlantic Canadian Communities. *Journal of Rural and Community Development, 6*(2), 170-182.

Sun, P.-C., Tsai, R. J., Finger, G., Chen, Y.-Y., & Yeh, D. (2008). What drives a successful e-Learning? An empirical investigation of the critical factors influencing learner satisfaction. *Computers & Education, 50*(4), 1183-1202.

Tallent-Runnels, M. K., Thomas, J. A., Lan, W. Y., Cooper, S., Ahern, T. C., Shaw, S. M., & Liu, X. (2006). Teaching courses online: A review of the research. *Review of educational research, 76*(1), 93-135.

The Educational Research Human Ethics Committee. (n.d.). Human Ethics Retrieved 15 February, 2014, from http://www.canterbury.ac.nz/humanethics/erhec/apply.shtml

TKI. (2014). *Technology Matrix*. Retrieved from http://ncea.tki.org.nz/Resources-for-Internally-Assessed-Achievement-Standards/Technology/Related-resources.

TKI. (n.d.-a). Achievement and learning objectives . Retrieved 8 November, 2014, from http://seniorsecondary.tki.org.nz/index.php/Technology/Achievement-and-learning-objectives

TKI. (n.d.-b). Assemble and Test Electronic and Embedded Systems Retrieved 8 November, 2014, from http://technology.tki.org.nz/Technology-in-the-NZC/What-does-learning-in-technology-look-like/Indicators-Learning-Objectives/Digital-Technologies/Assemble-and-Test-Electronic-and-Embedded-Systems

TKI. (n.d.-c). Develop an Electronic Environment. Retrieved 8 November, 2014, from http://technology.tki.org.nz/Technology-in-the-NZC/What-does-learning-in-technology-look-like/Indicators-Learning-Objectives/Digital-Technologies/Develop-an-Electronic-Environment

TKI. (n.d.-d). Learning Objectives:Knowledge of Electronic Environments. Retrieved 8 November, 2014, from http://technology.tki.org.nz/Technology-in-the-NZC/What-does-learning-in-technology-look-like/Indicators-Learning-Objectives/Digital-Technologies/Knowledge-of-Electronic-Environments

TKI. (n.d.-e). Literacy and language Retrieved 16 June, 2014, from http://literacyonline.tki.org.nz/Literacy-Online/Secondary-Literacy/Student-needs/Planning-for-learning/Literacy-and-language

TKI. (n.d.-f). *Managing copyright in schools.* Retrieved March, 17, 2013, from http://www.tki.org.nz/Copyright-in-Schools/Guidelines-for-schools/For-principals-and-trustees/Managing-copyright-in-schools

TKI. (n.d.-g). Technology in the NZC. Retrieved 26 October, 2014, from http://technology.tki.org.nz/Technology-in-the-NZC

Toprak, E., Ozkanal, B., Aydin, S., & Kaya, S. (2010). Ethics in e-learning. *TOJET, 9*(2), 78-86.

Tull, S. (2011). *Online Community Engagement through Simplicity, Relevance and Connection.* Paper presented at the ASCILITE-Australian Society for Computers in Learning in Tertiary Education Annual Conference, Tasmania, Australia.

Vygotsky, L. (1987). Zone of proximal development. *Mind in society: The development of higher psychological processes*, 52-91.

Walford, G. (2001). *Doing qualitative educational research: A personal guide to the research process*. London: Continuum.

Watson, J. (2008). Blending learning: The convergence of online and face-to-face education. *Promising Practices in Online Learning, North American Council for Online Learning*.

Wikipedia. (2014, 27 July 2014). No pain, no gain. Retrieved 5 August, 2014, from http://en.wikipedia.org/wiki/No_pain,_no_gain

Woo, M., Chu, S. K.-W., Ho, A., & Li, X. (2011). Using a Wiki to Scaffold Primary-School Students' Collaborative Writing. *Educational Technology & Society, 14*(1), 43-54.

Wright, N. (2010). *e-Learning and implications for New Zealand schools: A literature review*: Ministry of Education.

Yin, R. K. (2010). Building trustworthiness and credibility into qualitative research *Qualitative research from start to finish*. London: Guilford Press.

Zaka, P. (2012). *Blended teaching and learning in a New Zealand rural secondary school: using an ecological framework.* (Master of Education), University of Canterbury, Christchurch, New Zealand. Retrieved from http://hdl.handle.net/10092/7011 Available from University of Canterbury UC Research Repository database.

Appendices

Appendix 1. Key Literature Informing the Literature Review

Author(s) and year	**Type**	**Context/ sector/ subject (if applicable)**	**Focus**	**Data collection method(s)**
Anderson et al. (2001)	Literature review	Online teaching and learning	Assessing teacher presence in online course through design and organisation of online course, facilitating discourse and direct instruction	Content analysis of literature
Anderson (2009)	Empirical study	University	Comparing the effectiveness of formative feedback based on a paper system and online quizzes	Quiz results Student feedback
Carmichael and Farrell (2012)	Empirical study	University	Evaluation of an online learning site's effectiveness in developing students' critical thinking skills	Usage patterns, Questionnaire, Semi-structured telephone interview
Chambers, Carbonaro and Rex (2007)	Empirical study	Middle School	Case study researching students' knowledge development and problem solving approaches through the use of Lego robotics.	Students projects Reflective journals Observations Video
Chang (1999)	Position paper		A web-based learning instrument evaluating the effectiveness of online learning sites	Drawing on the literature
Clarke (2005)	Book	Secondary school	Formative assessment strategies	Drawing on the literature
Cole (2009)	Discussion paper	Higher education	Report on a failed action research experiment using Wikis to support student engagement and suggestions for improvement	Qualitative questionnaires Interviews
Garrison and Kanuka (2004)	Discussion paper	Higher education	Discuss blended learning and its potential to support deep and meaning learning, course structure, administrative and leadership issues influencing uptake of blended learning and suggestion for an action	Drawing on the literature

			plan to implement blended learning.	
Graham and Dziuban (2008)	Book chapter	Higher education	Identifies core issues and research in blended learning using the Sloan Consortium's five pillars (learning effectiveness, student satisfaction, faculty satisfaction, cost effectiveness and access) as an organising framework	Drawing on the literature
Harwood and Compton (2007)	Discussion paper	School	Review of history of technology education in NZ	Drawing on the literature
Jones and Issroff (2006)	Book chapter		Approach to teaching and learning with technologies to address student engagement	Drawing on the literature
Langenhorst (2011)	Empirical study	High school	Explore how online education is more, less or equally as effective as face-to-face instruction.	Student grades Interviews
Lunney, Frederickson, Spark and McDuffie (2008)	Empirical study	Higher education	Describing 10 strategies to develop critical thinking skills using online courses	Students' online postings
McGee and Fraser (2012)	Book	School	Textbook outlining a wide variety of skills and strategies for teacher professional development	Drawing on the literature
Moundridou and Kalinoglou (2008)	Empirical study	Secondary school	Report on the use of Lego Mindstorms robotics kit to support a course in Mechanical Engineering.	Assessment quiz Questionnaire
Ostashewski, Reid and Moisey (2011)	Empirical study	Teacher education	Report on the result of online teacher professional development in robotics using social networking	Observation of online activities Feedback
Shernoff, Csikszentmihalyi, Shneider and Shernoff (2003)	Empirical Study	High School	Investigation into high school students' way they spend their time and the conditions in which they are engaged.	Drawing on Literature Questionnaires at random times to determine current engagement
Stark and Woollard (2011)	Empirical Study	Higher Education	This paper explores the use of e-Portfolios and identifies strategies, processes and functionality that have implications for teachers	Drawing on Literature
Tallent-Runnels, Thomas, Lan, Cooper, Ahern, Shaw and Liu (2006)	Discussion paper	Online teaching and learning	Summarises research in online teaching and learning in four topics: course environment, learners' outcomes, learners' characteristics, and institutional and	Drawing on Literature

			administrative factors	
Watson (2008)	Literature review	School	Explore practises in blended learning to support innovative teaching and learning strategies	Review of the literature on good teaching and learning practices in blended learning
Wright (2010)	Discussion paper	School	Review outlining evidence linking e-Learning to improved student learning outcomes and teaching and learning practices that maximises benefits of e-Learning.	Drawing on the literature
Zaka (2012)	Master Thesis – Empirical study	Secondary school	Case study investigating implementation of blended teaching and learning practices in a New Zealand rural secondary school.	Document reviews Observations Group interviews Individual interviews

Appendix 2. WEBLEI

Summary of WEBLEI scale from Chang (1999)

Access *WEBLEI Scale I: Emancipatory activities* 1 I can access the learning activities at times convenient to me 2 I am allowed to work at my own pace to achieve learning objectives. 3 I decide how much I want to learn in a given period 4 It is useful for me to have a computer at home to access this course 5 I was given just the right amount of assignments 6 I decide what I want to learn	**Interact** *WEBLEI Scale II: Co-participatory activities* 1 In this learning environment, I have to be self-disciplined in order to learn. 2 This mode of learning enables me to interact with other students and the tutor asynchronously (not at the same time). 3 The asynchronous nature of the interactions enables me to reflect and respond when I have formulated an appropriate response/answer. 4 I communicate with other students in this subject electronically (via email, or forum). 5 I feel I can ask my teacher or online facilitator what I do not understand. 6 My teacher or online facilitator responds promptly to my queries. 7 I can ask other students what I do not understand. 8 It is easy to work collaboratively with other students involved in a group project. 9 I would like to learn more about robotics as a result of this course 10 The teaching staff of this unit motivated me to do my best work.
Response *WEBLEI Scale III: Qualia* 1 I felt a sense of satisfaction and achievement about this learning environment. 2 I enjoy learning in this environment. 3 I could learn more in this environment. 4 The technology resources enhance learning. 5 I was supported by positive attitude from my peers. 6 I was able to access the materials without much difficulty. 7 I had no difficulty using the technology. 8 I am confident in using the technology. 9 I have no problems going through the materials on my own. 10 I was in control of my progress as	**Results** *WEBLEI Scale IV: Information structure and design activities* 1 The learning objectives are clearly stated in each lesson. 2 The scope of the lesson is clearly stated. 3 I had a clear idea of what was expected of me in this unit. 4 The organisation of each lesson is easy to follow. 5 The structure keeps me focused on what is to be learned. 6 Expectations of assignments are clearly stated in my subject. 7 Activities helped me to understand the material 8 The subject content is appropriate for delivery on the Web. 9 There is a logical sequence of presentation of the subject content. 10 The presentation of the subject content is clear. 11 The quiz in the web-based materials enhances my learning process. 12 The material shows evidence of originality and

I moved through the material. 11 It was easy to move about in the material. 12 The web based learning environment held my interest throughout my course of study.	creativity in the visual design and layout. 13 The graphics used in the material are appropriate. 14 The colours used in the material are appropriate. 15 The use of on-line technologies in this unit enhanced my learning experience. 16 The links provided in the material are clearly visible and logical. 17 The 'Help' section included in the material is helpful. 18 The web based learning approach can substitute traditional classroom approach. 19 The web based learning approach can be used to supplement traditional classroom approach.

Appendix 3. Code of conduct

The purpose of the code of conduct is to ensure that all students can safely use the online environment without fear of emotional, cultural or psychological harm. The school has its own code of conduct that need to be adhered to for the duration of this course. Further to this will be certain expectations students need to adhere to as participants in the robotics course. Student need to sign this form to agree to these guidelines. For the purpose of this course some of the IT guidelines for the school will be duplicated to clarify further expectations. This code of conduct is separated into the following areas:

- Care of hardware
- Online behaviour (netiquette)
- Appropriate use of online resources
- General expectations

Appendix 3.1 Care of Hardware

- Students are required to only use all hardware for the intended purposes as per the school's IT guidelines
- The robot kits needs to be handle with care. These are sensitive equipment.
- The robot kits will not be modified in such a way that it cannot be reused. If in doubt about this, talk to your teacher.
- If parts of the robot kits needs to be repaired it has to be done under the teacher's supervision.

Appendix 3.2 Online behaviour (netiquette)

- Appropriate interaction with others in online forums, showing respect for all viewpoints. With online discussions there will be no criticism to any person's viewpoints, spelling, grammar or any typos but you are expected to express yourself if you disagree and outline why. Remember we are criticising viewpoints, not the person. The same goes for if you agree. Say that to the person so that we create a positive environment.
- All interactions will be related to the course material except in the Social Forum. General IT guidelines still apply.
- All e-mail messages need to be appropriate as per the IT guidelines.

Appendix 3.3 General expectations

As participants in the robotics course, students are expected to:

- Regularly log on to check messages, news items and course work
- Read through provided resources. Follow the links to find out more about the topic
- Complete activities as instructed
- Collaborate online with fellow students as required
- Submit assignments online by the due date
- Work through resources at home and use class time to build and program the robots
- Any questions about the course should be posted in the forum "General Discussions". Any member of this course may answer questions and are encouraged to do so.
- Any questions about problems should be posted in the forum "Help". Any member of this course may answer questions and are encouraged to do so. This will be turned into a FAQ section
- Talk to or e-mail fellow students or classroom teacher if they are struggling to understand what is expected.

I, ____________________(*your name*) agree to the above guidelines. I understand that the school's IT guidelines form part of this agreement.

________________________________ _____________

Signature Date

Appendix 3.4 Appropriate use of online resources

Usage of the Internet for educational purposes as outlined by the robotics course

- Use of appropriate websites and evaluation of reliability of websites before using. The course will provide links to most of the websites needed
- Security with respect to usernames and passwords – do not share passwords

Appendix 4. Letters to Participants

Appendix 4.1 Information Letter to Principal

College of Education

School of Literacies and Arts in Education
Tel: +64 3 343 9606, Fax: + 64 343 7790

Information for the School

To the Principal

Project title: Learning Robotics Online: Teaching an online robotics course for secondary school students.

My name is Katana Dunn and I am a Masters student at the College of Education, University of Canterbury. The purpose of my research is to find out if an online robotics course can be used for teaching robotics. The main research question is how an online course can be used by classroom teachers, to teach a course in robotics in the senior secondary school.

The robotics online course will be hosted on your schools' Moodle platform. The development of the robotics course is designed to reflect a more accurate real-world experience taking into account current accepted practices. The advantage of this approach is that the students take responsibility for their own learning and most importantly, learning robotics online can help create 21st Century self-directed, motivated learners, one of the Ministry of Education's goals for students.

This course unit is over eight weeks and is part of the Y13 Electronics Technology course. Students, who decided not to participate in the research aspect, will still take part in all learning opportunities. If they do participate, they have the right to withdraw from the study at any time without penalty. If they withdraw, I will do my best to remove any information relating to them, provided this is practically achievable.

As part of the study, I would like the students to engage with the provided online robotics course. Guidelines will be provided. Data will be gathered, with students' informed consent, on their learning products, processes and experiences throughout the course duration. I will observe and document all activities and processes during the course including emerging reactions based on students' achievements and progress.

I will conduct a 30-minute semi-structured interview with the students and classroom teacher at the end of the course. I would like to do that in school time on your premises. The outline of the interview questions will be available beforehand. Interview times will be negotiated with the school.

All information will be treated in strictest confidence, all participants will remain anonymous. All data will be securely kept by the researcher and any data that can identify the participants will not be given to any other researcher or agency. As required by the University's research policy, at the completion of the project all information collected will be retained in secure storage for five years, after which it will be destroyed. The results of the study may be submitted for publication to national or international journals or presented at educational conferences. You may at any time ask for additional information or results from the study. Reasonable precautions will be taken to protect privacy of data transmitted through the Internet.

If you would like more information or have any questions about the research, you can contact me or my supervisor, Wendy Fox-Turnbull (wendy.fox-turnbull@canterbury.ac.nz). If you have any concerns or complaints about this research, please see the contact details below. If you are happy to take part you will need to sign the consent form and return it to me. Please retain this information sheet. Thank you for your consideration of this research project.

Katana Dunn (katana.dunn@pg.canterbury.ac.nz)

Phone: [redacted]

Cell: [redacted]

This project has received ethical approval from the University of Canterbury, Educational Research Human Ethics Committee.

Complaints may be addressed to:

The Chair,
Educational Research Human Ethics Committee
University of Canterbury, Private Bag 4800, Christchurch

Email: human-ethics@canterbury.ac.nz

Appendix 4.2 Consent Letter to Principal

College of Education

School of Literacies and Arts in Education Tel: +64 3 343 9606, Fax: + 64 343 7790

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Project title: Learning Robotics Online: Teaching an online robotics course for secondary school students

School Consent Form

I understand the aims and purposes of the research study undertaken by Katana Dunn

- The study has been explained to me and I understand the information that was given to me on the information sheet.
- I am aware that my school's participation in this project is voluntary. I have had all questions answered to my satisfaction.
- I understand that the school's involvement will include providing a room for the student interviews.
- I understand that the school can withdraw from the study at any time, without giving any reason for withdrawing.
- I understand that all information will be treated in strictest confidence, that participants will remain anonymous and that no information that could identify me will be given to other researchers or agencies. I understand that reasonable precautions have been taken to protect privacy of data transmitted through the internet
- I understand that within these restrictions, the findings may be submitted for publication to national or international journals or presented at educational conferences; that the results of the study can be made available to me at my request and that I can request additional information at any time.
- I have read the information sheet and consent form. I agree for XXXXX school to participate in the study.

Name: ____

Position: ____

Signed: ____

Date: ____

Please return this form to: ***Katana Dunn***

[redacted]

Using the self-addressed envelope provided

Appendix 4.3 Information Letter to Teacher

College of Education

School of Literacies and Arts in Education
Tel: +64 3 343 9606, Fax: + 64 343 7790

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Information for the Teacher

Project title: Learning Robotics Online: Teaching an online robotics course for secondary school students

My name is Katana Dunn and I am a Masters student at the College of Education, University of Canterbury. The purpose of my research is to find out if an online robotics course can be used for teaching robotics. The main research question is how an online course can be used by classroom teachers, to teach a course in robotics in the senior secondary school. To answer the above question the following research questions will be addressed:

- How can an online robotics course adequately address and advance student learning outcomes? How is student achievement measured?
- What aspects of on-line course design are successful for teaching robotics?
- What types of online learning experiences provide a positive outcome for students?

I would like to invite you to participate in this research as your reflections and opinions would be valuable data. If you do participate, you have the right to withdraw from the study at any time without penalty. If you withdraw, I will do my best to remove any information relating to you, provided this is practically achievable.

The development of the online robotics course is designed to reflect a more accurate real-world experience taking into account current accepted practices. This course will run over eight weeks. The advantage of this approach is that the students take responsibility for their own learning and most importantly, learning robotics online can help create 21st Century self-directed, motivated learners, one of the Ministry of Education's goals for students. The students will be expected to work in groups to develop their robots, individually participate in online forums and individually reflect on their learning using e-Portfolio. This course will be based around an Antarctic theme and students will be able to complete one or two NCEA achievement standards.

This course unit is over eight weeks and is part of the Y13 Electronics Technology course. As part of the study, I would like you to engage with the provided online robotics course, participate in forums when required to support students and engage with me in informal discussions about the course and the students. I would also like you to keep a journal of your reflections. I will conduct a 30-minute semi-structured interview with you at the end of the course. The outline of the interview questions will be available beforehand.

All information will be treated in strictest confidence and you will remain anonymous. I will keep all data securely any data that can identify you will not be given to any other researcher or agency. As required by the University's research policy, at the completion of the project all information collected will be retained in secure storage for five years, after which it will be destroyed. The results of the study may be submitted for publication to national or international journals or presented at educational conferences. You may at any time ask for additional information or results from the study. Reasonable precautions will be taken to protect privacy of data transmitted through the Internet.

If you would like more information or have any questions about the research, you can contact me or my supervisor, Wendy Fox-Turnbull (wendy.fox-turnbull@canterbury.ac.nz). If you have any concerns or complaints about this research, please see the contact details below. If you are happy to take part you will need to sign the consent form and return it to me. Please retain this information sheet. Thank you for your consideration of this research project.

Katana Dunn (katana.dunn@pg.canterbury.ac.nz)

Phone: [redacted]

Cell: [redacted]

This project has received ethical approval from the University of Canterbury, Educational Research Human Ethics Committee.

Complaints may be addressed to:
The Chair,
Educational Research Human Ethics Committee
University of Canterbury, Private Bag 4800, Christchurch
Email: human-ethics@canterbury.ac.nz

Learning Robotics Online

Appendix 4.4 **Consent Letter to Teacher**

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

College of Education

School of Literacies and Arts in Education Tel: +64 3 343 9606, Fax: + 64 343 7790

Project title: Learning Robotics Online: Teaching an online robotics course for secondary school students

Teacher Consent Form

I understand the aims and purposes of the research study undertaken by Katana Dunn

- The study has been explained to me and I understand the information that was given to me on the information sheet.
- I am aware that my participation in this project is voluntary. I have had all questions answered to my satisfaction.
- I understand that I can withdraw from the study at any time, without giving any reason for withdrawing.
- I understand that all information will be treated in strictest confidence, that participants will remain anonymous and that no information that could identify me will be given to other researchers or agencies. I understand that reasonable precautions have been taken to protect privacy of data transmitted through the internet
- I understand that within these restrictions, the findings may be submitted for publication to national or international journals or presented at educational conferences; that the results of the study can be made available to me at my request and that I can request additional information at any time.
- I understand that student interviews will be recorded. I will be provided with a copy of interview transcript to check for accuracy.
- I have read the information sheet and consent form. I agree to participate in the study.

Name: ____

Signed: ____

Date: ____

Please return this form to: Katana Dunn
[redacted]

Using the self-addressed envelope provided

Appendix 4.5 Information Letter to Students

College of Education

School of Literacies and Arts in Education
Tel: +64 3 343 9606, Fax: + 64 343 7790

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Information for the Students

Project title: Learning Robotics Online: Teaching an online robotics course for secondary school students

My name is Katana Dunn and I am a Masters student at the College of Education, University of Canterbury. The purpose of my research is to find out if an online robotics course can be used for teaching robotics. I will be looking at how the course can help you with your learning. To do this, I will develop an online course for Robotics, using current practices. Using this course I will explore aspects of on-line course design and online learning experiences to determine how well they support the teaching of robotics.

I would like to invite you to participate in this research. This course unit is over eight weeks and is part of the Y13 Electronics Technology course. You will be expected to work in groups to develop robots, individually participate in online forums and individually reflect on your learning using e-Portfolio and you will be able to complete one or two NCEA achievement standards if you wish to.

If you decide not to participate in the research aspect, you will still take part in all learning opportunities. If you do participate, you have the right to withdraw from the study at any time without penalty. If you withdraw, I will do my best to remove any information relating to you, provided this is practically achievable. If you consent, data will be gathered on your learning products, processes and experiences throughout the course duration. I will observe and document all activities and processes during the course. I would also like to conduct a 30-minute interview with you in school time after the end of the course.

All information you tell me will be kept confidential. I will keep all data gathered in a secure place and you will not be able to be identified in the write up of the study nor in subsequent publications. The results of the study may be submitted for publication to national or international journals or presented at educational conferences. You may at any time ask for additional information or results from the study. Reasonable precautions will be taken to protect privacy of data transmitted through the Internet.

If you would like more information or have any questions about the research, you can contact me or my supervisor, Wendy Fox-Turnbull (wendy.fox-turnbull@canterbury.ac.nz). If you have any concerns or complaints about this research, please see the contact details below. If you are happy to take part you will need to sign the consent form and return it to me. Please retain this information sheet. Thank you for your consideration of this research project.

Katana Dunn (katana.dunn@pg.canterbury.ac.nz)

Phone: 358 5694

Cell: 021 257 3820

This project has received ethical approval from the University of Canterbury, Educational Research Human Ethics Committee.

Complaints may be addressed to:

The Chair,
Educational Research Human Ethics Committee
University of Canterbury, Private Bag 4800, Christchurch

Email: human-ethics@canterbury.ac.nz

Appendix 4.6 Consent Letter to Students

College of Education

School of Literacies and Arts in Education Tel: +64 3 343 9606, Fax: + 64 343 7790

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Project title: Learning Robotics Online: Teaching an online robotics course for secondary school students

Student/ Parent Consent Form

I understand the aims and purposes of the research study undertaken by Katana Dunn

- The study has been explained to me and I understand the information that was given to me on the information sheet.
- I have discussed this study with my parent/caregiver
- I am aware that my participation in this project is voluntary. I have had all questions answered to my satisfaction.
- I understand that I can withdraw from the study at any time, without giving any reason for withdrawing.
- I understand that all information will be treated in strictest confidence, that participants will remain anonymous and that no information that could identify me will be given to other researchers or agencies. I understand that reasonable precautions have been taken to protect privacy of data transmitted through the internet
- I understand that within these restrictions, the findings may be submitted for publication to national or international journals or presented at educational conferences; that the results of the study can be made available to me at my request and that I can request additional information at any time.
- I understand that student interviews will be recorded. I will be provided with a copy of interview transcript to check for accuracy.
- I have read the information sheet and consent form. I agree to participate in the study.

Student Name: ____

Signed: ____

Date: ____

Parent Consent

I have discussed this project with __________________________________ and am happy that he understands what he will be asked to do and that he can withdraw at any stage. I agree for my child to participate in the study.

Parent Name: ____

Signed: ____

Date: ____

Please return this form to Mrs XXXXXX electronic technology teacher XX High School

Appendix 4.7 Information Letter to Parents

College of Education
School of Literacies and Arts in Education
Tel: +64 3 343 9606, Fax: + 64 343 7790

Information for the Parents/Caregivers

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Project title: Learning Robotics Online: Teaching an online robotics course for secondary school students

My name is Katana Dunn and I am a Masters student at the College of Education, University of Canterbury. The purpose of my research is to find out if an online robotics course can be used for teaching robotics. The main research question is how an online course can be used by classroom teachers, to teach a course in robotics in the senior secondary school.

I would like to invite your child to participate in this research. This course unit is over eight weeks and is part of the Y13 Electronics Technology course. The robotics online course will be hosted on the schools' Moodle platform. The development of the robotics course is designed to reflect a more accurate real-world experience taking into account current accepted practices. The advantage of this approach is that the students take responsibility for their own learning and most importantly, learning robotics online can help create 21st Century self-directed, motivated learners, one of the Ministry of Education's goals for students. The students will be expected to work in groups to develop their robots, individually participate in online forums and individually reflect on their learning using e-Portfolio. Students will be able to complete one or two NCEA achievement standards if they wish to.

Students, who decide not to participate in the research aspect, will still take part in all learning opportunities. If they do participate, they have the right to withdraw from the study at any time without penalty. If they withdraw, I will do my best to remove any information relating to them, provided this is practically achievable.

Data will be gathered, with students' informed consent, on their learning products, processes and experiences throughout the course duration. I will observe and document all activities and processes during the course including emerging reactions based on students' achievements and progress. I will conduct a 30 minute semi-structured interview with each student in school time at the end of the course. The outline of the interview questions will be available beforehand.

All information will be treated in strictest confidence, all participants will remain anonymous. All data will be kept by the researcher and any data that can identify the participants will not be given to any other researcher or agency. As required by the University's research policy, at the completion of the project all information collected will be retained in secure storage for five years, after which it will be destroyed. The results of the study may be submitted for publication to national or international journals or presented at educational conferences. You may at any time ask for additional information or results from the study. Reasonable precautions will be taken to protect privacy of data transmitted through the Internet.

If you would like more information or have any questions about the research, you can contact me or my supervisor, Wendy Fox-Turnbull (wendy.fox-turnbull@canterbury.ac.nz). If you have any concerns or complaints about this research, please see the contact details below. If you are happy to take part you will need to sign the consent form and return it to me. Please retain this information sheet. Thank you for your consideration of this research project.
Katana Dunn (katana.dunn@pg.canterbury.ac.nz)

Phone: [redacted]
Cell: [redacted]

This project has received ethical approval from the University of Canterbury, Educational Research Human Ethics Committee.

Complaints may be addressed to:
The Chair,
Educational Research Human Ethics Committee
University of Canterbury, Private Bag 4800, Christchurch
Email: human-ethics@canterbury.ac.nz

Appendix 5. Robotics Interfaces course unit plan

Strands: Electronics and Control	Digital Society

Unit title: Robotics Interfaces

Year 13 – NZ Curriculum Technology level eight

Version 1

Introduction
The goal of this unit is to motivate the student to study electronics, programming and technology by exploring aspects of the technology curriculum in a fun and exciting way. Using an online course environment can help students develop 21st Century skills to become self-directed motivated learners. They also learn how to use the online environment as well as communicate online in an ethical and responsible way within a closed, supportive structure. Using an online course to support classroom teachers can make it easier to address diversity and different learning styles of the students. Students explore various aspects of robotics through team work and self-directed study. This unit explores the use of robotics in Antarctica and how that influences the design, construction and programming of a robot. They explore aspects of environmental and sustainability issues to design and develop an appropriate robot using the technological process. Students practise the processes and use project management guidelines used in industry projects. The outcome of this unit is to create a robot to be used in Antarctica to transport and lift heavy objects like solar panels. Although standard commercially available kits are provided students are expected to design, construct and develop their one interface as well using PCB production software. The teachers will be the stakeholders.

DTG	NZ Curriculum

Key Indicators:

Electronics and Control

- Develop high quality and reliable solutions
- Use, design, test, evaluate, refine and justify outcomes
- Design and model a prototype for an outcome
- Effectively document systems and procedures to achieve a solution
- Collate stakeholder feedback to refine a solution

Digital Society

- Explore and discuss emerging trends in digital technologies
- Identify and discuss solutions to the impact of digital technologies on society – locally and globally
- Examine legislation and codes of practice within the digital technology field
- Examine the enterprising use of digital technologies in local and global settings
- Examine and explore the issues and impact of sustainability and environmental impact of digital technologies

Digital Technologies focuses on applying and knowing about computer science, electronic and digital applications.

The critical knowledge/skill or component/s of practice that you expect the student to develop.

- Learning to construct and program a robot built with a RoboCircle.
- Design and develop a robot to complete a complex challenge
- Developing programming skills to achieve complex tasks
- Collaborative working in teams and individually
- Develop online communication skills
- Develop Critical reflection skills

To have fun!

Curriculum focus

Technology: Technological practice

Students critically examine the use of robotics in specific environments and construct and program a robot. They use project management practices to ensure the efficient development of their robot to a specified brief. They critically evaluate and justify their design for fitness of purpose.

Technology: Technological Knowledge

Students explore various aspects of robots and their use in society. They develop an understanding of the technologies involved in building a robot to specification. They learn to evaluate the purpose for each component that makes up a robot system.

Key Competencies and Values

Relating to others

- Students work in teams to develop robots to meet defined briefs.
- Students must demonstrate willingness both online and face-to-face to listen actively, recognise different points of views, negotiate and share ideas.

Using language symbols and texts

- Learning to construct and program a robot built with the RoboCircle. Students explore the basic building blocks of this robot to inform their own designs.
- Students must demonstrate resourcefulness: knowing where to find information about robots and how to authenticate the data.
- Students develop effective communication skills - written and visual (online) to show their understanding of the topic.
- Students explore different computer programs including programming principles and techniques

Managing self

Students will need to establish their needs and the processes that they will undertake to construct their robot. Through self-motivation

	they must establish their own personal goals, make plans, timelines, and ensure that they develop the skills to present their final product. They must ensure that they set and meet milestones to guarantee that they complete their assigned task on time. On-going online interactions and reflections required.

Assessment opportunities

Achievement standard 3.48 – Implement complex interfacing procedures in a specified electronic environment

Achievement standard 3.49 – Implement complex interfacing techniques in constructing a specified electronic environment

Both these are internal assessments and the weekly online interactions, the on-going project outcomes, classroom discussions, weekly quizzes and student reflections on e-Portfolio including their final reports and interviews all form part of the assessment. These are used to triangulate the data and ensure student output authenticity. Therefore students' on-going reflection showing the development of their thinking, knowledge and skills form a vital part to show they have done the work themselves.

Assessment rubric required – link to assessment schedule for "Develop lift interfaces"(3.48) and "Lift" (3.49)

Student prior knowledge

Understanding of design principles.

Basic measurement skills using multimeters (oscilloscope may be beneficial)

Circuit design techniques, circuit constructions, testing and fault finding techniques

PCB production and soldering techniques

Basic Application and Data Management skills:

- Internet.
- Word processing software
- E-Portfolio or Wikis
- Understanding graphic design principles (CRAP) to create easy-to-read and well-presented documentation and online pages

Resources required

Students preferably have their own laptops

Access to Moodle

Access to e-Portfolio

Video Cameras

Image capturing software like *Jing*

Resources supplied

- Inex RoboCircle 3S – See Appendix A
- Computers with Cricket Logo software
- Tutorials for interfacing with a DC and stepper motors, sensors and LED's (extrapolate to 7-segment LEDs), infrared communications
- Technical information on hardware interfaces as background to developing own interfaces.
- User manuals including standard instructions and programming descriptions
- Templates and worksheets
- Videos, podcast and simulations to explain aspect of the topic.

Special notes

This is an online course for Robotics. All information will be available online. Students are expected to interact online with teacher, instructor and peers. Discussion forums will be set up for each section and a general and help forums as well.

Components and other parts are supplied but students are expected to use their own components and equipment as well. Various components like motors, LED, switches are also available in old printers and scanners and students learn that we don't have to buy everything but recycle what is available. This creates clever ways to be innovative. For students who are planning to use a stepper motor gearing system some mechanical workshop work may be required depending on their designs. This should be discussed with their teacher (Set solutions can be provided).

Some online material may be hosted on the Technotutorz Moodle (http://courses.technotutorz.co.nz/) as videos cannot always be uploaded to Moodle effectively. Access to these courses is limited but all Technotutorz students can get access.

General idea of teaching and students working in teams of two. One face-to-face for Katana and available online the rest of the week with classroom teacher lead students where necessary. Students will be expected to interact online and log on at least 5 days a week. Students should work at home doing most of the reflections, quizzes, planning and other work that doesn't require programming and use classroom time effectively programming robots or other work that can only be done at school.

A Code of conduct, signed by students, to guide their online behaviour, ethical use of the online environment, how they interact with peers and how they use the hardware is essential.

This is a practical unit but students are required to understand the theory of design and how the interfaces function. This becomes background information for students to create their own interfaces to implement the brief. They are expected to interact online regularly, reflect on their e-Portfolios, add evidence in the form of videos, images and other material with descriptions to show that they have completed activities and how that may be used or influence future designs. The development of their e-portfolio reflections should be done in such a way that it can be used as the bases for their final report.

Visit to Antarctic centre before start of course will give students an awareness of the environment.

Industry speakers (Could be through the Antarctic visit)? Demonstration at end to Senior Management?

Learning experiences	Resources/special notes
Introduction 1.1.1.1 Students brainstorm robotics through the following questions: • What is a robot? • What can a robot do? • Where are robots used /found? • Why are robots used in Antarctica? • How are robots used in Antarctica? • What can be future application for robots in Antarctica? Online course provide links to websites to explore in a form of a Webquest. Students interact in online forums to discuss these questions. They are expected to complete the Webquest to build background knowledge. Students interact online as individuals in the online forums. Criteria are set for the number of interactions and quality as part of the assessment rubric. Quiz to test how well they remember what they have read.	Specific Learning Outcomes: • Be able to critically reflect on the questions ask on their e-Portfolio • List of criteria for own robots in specified environment • Show reflections on e-Portfolio Try to get students to think about the impact of robots in Antarctica, how robots can benefit the environment, any perceptions regarding the ethical and cultural use of robots and the future of robotics in Antarctica. From this discussion students should come up with a list of criteria for their own robots. The topic should allow students to demonstrate a range of skills within the one unit and in a manner that they can continually build on using a range of components as they work through all the processes. The idea is that they will be able to go back and fill in gaps, rebuilding, refining and taking responsibility to create the best robot that they are capable of producing. This is an eight week unit so to help the students give them a skeleton outline of what they should aim to achieve from week to week and they can modify and reshape it to suit their own needs. Basically there would be minimum requirements every week but students (especially for Excellence students) should complete extra activities to achieve well. It is important for them to keep up so that they are able to complete the requirements for the two achievement standards. After the eight weeks students should have time to complete their reports. Webquest Discussion Forum Quiz
Build a standard RoboCircle: Round base Set up teams using Choice on Moodle. (Classroom Teacher should have a say as well as she knows the students well)	**Specific Learning Outcomes:** Students will be able to • Identify different parts of the robot kit and what it does • Explain the functions of the sub systems • Identify inputs and outputs on the microcontroller • Use these parts to complete a basic robot for

	learning • Show reflections on e-Portfolio including photos **Required:** Standard RoboCircle kit and instructions This standard robot should be completed in less than a period. They start off just adding the motors and microprocessor to the base. This enables students to start with programming. The sensors can be added later as outlined in the instructions provided.
Basic programming: Programming interface, basic command in Cricket Logo for movement (DC motors), reading sensors and digital outputs Complete activities: Switch control LEDs, Basic movement (Forward, backward, rotate/pivot, one-motor turn and circles), use touch sensors to stay in a cage while moving continuously, using distance sensor to stop at a wall and light sensor to stop at a line Students discuss in online Forum • What are the strength and limitations of this robot • What aspects need to be considered when using the light sensor? • What aspects need to be considered when using the distance sensor? Quiz – Check understanding of functions Student reflection on e-Portfolio, Students create video evidence of their work and image capturing of the code	**Specific Learning Outcomes:** Students will be able to • Choose appropriate filenames • Identify different aspects of the programming interface and what it does and how to use it • Demonstrate how to program the RoboCircle to complete basic tasks • Critically reflect on the robot's strengths and limitations • Critically reflect on the different sensors and how it can be used • Show reflections on e-Portfolio including photos, videos **Required:** Cricket Logo application and robots Students get familiar with commands and operation of hardware with assigned activities Virtual Cricket Logo program for students to practise at home Activities outlined on Moodle from the **Inex RoboCircle curriculum** (Robo-Circle3S_E.pdf).Students need to know what the "raw values" as measured by the sensors mean **Discussion Forum.** Students should be able to ask their own questions. If possible get students responsible for the forums and whilst the teacher creates starter questions the students should take responsibility after that Quiz

Advanced Programming: Programming structures: Sequential, Loops, If,	**Specific Learning Outcomes:** Students must be able to

Procedures Multi-tasking and recursion Documentation Variables Testing and debugging Sound Online forum – Questions to enable students to critically reflect on how the program can be used to solve engineering problems Quiz Student reflection on e-Portfolio, Students create video evidence of their work and image capturing of the code	• Determine when to use each type of programming structure • Appropriately document code • Demonstrate how multitasking and recursion can be used • Use agile programming techniques in program development • Demonstrate the use of variables and explain how it works • Demonstrate appropriate testing strategies • Follow a documented testing cycle • Use the help file and other documentation • Demonstrate how sound can be used including for testing purposes • Show reflections on e-Portfolio including photos, videos The purpose of this section is to make students more knowledgeable about different aspect of the Cricket Logo software and how it can be used to create more complex programs. Discussion Forum Quiz Students to reflect on e-portfolio and summarise online discussion for their own use.
Interface Design Analyse interfaces to create specs to use for own designs Two-phase Stepper motor control 7-segment LED display and demultiplexers Current sensing Temperature sensing Flasher circuits Infrared comms? **Online forum:** Discuss the use of the above designs. Discuss more options for addons Quiz Student reflection on **e-Portfolio**	**Specific Learning Outcomes:** Students must be able to • Show the specifications of each interface • Develop additional interfaces to use with their robot • Describe additional interfaces to demonstrate understanding and design • Describe why these interface are fit for purpose • Show reflections on e-Portfolio including photos, videos Explore various designs that can be used as add ons to the basic robot kit. Many of these should provide extensions activities for Merit and Excellence students Discussion Forum Quiz Students to reflect on e-portfolio and summarise online discussion for their own use.
Robot Design for Antarctica	**Specific Learning Outcomes:**

Engineering development process Brief development Plans Design Components Parts –track wheels, robot parts, calculations, motors/steppers, battery, micro-controller, sensors. Control systems and the use of feedback Design – then build - robot chassis (concepts only at this stage) Look at other tips KISS approach Online Forum Student reflection on e-Portfolio	Students must be able to • Analyse requirements • Develop a brief for their own design • Create a time plan with task to ensure they finish on time • Identify resources required for their designs • Show reflection on e-Portfolio including photos, videos RoboCircle with track wheels and other parts as listed in Appendix A Moodle Internet Introduce Assessment Discussion Forum: Discuss issues relating to the assessment Quiz – Not sure of a quiz at this stage but a general may be added Students to reflect on e-portfolio and summarise online discussions for their own use. Add ideas about initial thinking and synthesise assessment to ensure requirements are clear.
Understand the concept of planning Although planning is not assessed students need to follow a plan to ensure they complete assessment on time. It is also a good habit to practise. Students review the planning process: Goals, deliverables, schedules, plans, budgets etc. Importance of planning. Students are guided through the first stage of the plan of action. Emphasis is on managing self by establishing personal goals, making plans and meeting them. Online discussions to enable students to critically reflect on the importance of planning and project management in industry Students reflections	**Specific Learning Outcomes:** Students must be able to • Understand the basics concepts of planning • Set goals, create plans etc to manage their project • Show reflections on e-Portfolio Template should be available Classroom teacher have a better understanding of the guidance required at this point as these students have done this before. She may decide to do this as a face-to-face class or discuss with individuals. This section could only be about providing a template but there should be on-going individual discussions with students to ensure they are on track. To keep to an online theme students may be expected to create their plans online and the teachers can provide feedback on their e-portfolio pages Discussion Forum: Planning issues, theory of planning etc Quiz – Not sure of a quiz at this stage but a general one

<table>
<tr><td></td><td>may be added

Students to reflect on e-portfolio and summarise online discussion for their own use. Add ideas about initial thinking and synthesise assessment to ensure requirements are clear.</td></tr>
<tr><td>Construction and implementation of chosen plan

Process:
Task 1 – develop preliminary design Sheet. (includes homework time)
Task 2 – research on current developments – Most of this should have been done in introduction
Task 3 – Robot Design
Task 4 – Evaluation, Design Review
Task 5 - Construct, program and test robot
Task 6 – Demonstration (Milestone)
Task 7 -Complete final write-up, self-evaluation and report and submit assessment</td><td>Stage One Plan of Action

At the beginning of each stage brainstorm with the students' ideas of what needs to be completed in order to achieve their goal. They prepare their plan of action for that stage according to what suits their purpose. This will enable them to manage their project within the specified timeframe. At the end of each stage they assess their progress and ensure that they have worked out what they need to carry over to the upcoming stage.(Students may do this by themselves)

Students need to understand this is an iterative process.</td></tr>
<tr><td>Plan robot design

Before students begin to create their robot they need to be aware of the importance of appropriate planning and design. This is essential in the initial preparation to ensure that the requirements are met.

Students used the knowledge they gained from the introduction, programming and interface design sections as well as their own research to plan their own designs.

Students need to identify components/ parts required

Create concept drawings. They can scan these to the e-portfolio site. Evaluate software issues, interface designs and other requirements for their robot design

Students complete design plans and submit for design reviews.

Get components/parts together and update reflections</td><td>Stage Two Plan of Action

The second stage of this project is designing the robot to the required brief.

Discussion Forum: If classroom teacher is happy with this, ideally these design reviews should be conducted with all students. As the designs have been done and the teacher has approved them for design review stage, I think open design reviews would benefit the students. Each team can manage a discussion form where they present their design and others critique it. These critiques should form part of the individual student's assessment. If at this point students decide to use other's ideas I think it shouldn't matter as long as it is all appropriately documented and the student who uses other's ideas can explain it in his own words. This is the reality in industry as we can use information and modify for our use. Students should explain their thinking. There may be copyright and patent issues and these needs to be considered. Students should also reference where information comes from.

Students reflections</td></tr>
</table>

Design reviews –By teachers (and then peers) Only after design is approved do students go to the next face as expected in industry.	
PCB layouts While the students are planning projects and design introduce them to PCB layout to use for own designs. Practise schematics and layouts Layout rules and techniques Online Forums Students reflections	Students may have enough knowledge of this but this phase is required for those not confident with PCB design. http://www.circuits.io/ Discussion Forum: Questions on effective layouts, rules, techniques, issues with layout Quiz?
Build robot to specified to design Build robot using components/parts. Workshop work may be required Students may decide to build parts of the robot, test it first before continue the process	Stage Three Plan of Action Students build their robots using the provided kits, other components and parts as needed. PCB manufacturing, soldering and access to workshop required
Program and Test Students create code to test sections of the design using agile programming techniques. Document code and use versions to develop code. Online Forums Students reflections	**Stage Four Plan of Action** The concept of version control is important in planning. As this is not assessed the documentation showing alteration may not be as important. This would be the assessors judgement On-going development and changes to the robot and software can take place but each alteration needs to be documented with justification and reasons for change. As development occurs students need to ensure appropriate functionality and documentation of outcomes ie robot functionality tested and appropriate documentation and documented software provided A final check to ensure all specifications are met needs to occur. This includes a functioning robot, documented software and other supporting documentation. All software has to be error-free and grammatically correct. Students to check rubric for ensure criteria met. Discussion Forum: Could have some critical questions

	or guiding questions to ensure students on track. Checklist questions?
Demonstration and finalise documentation Students to demonstrate final design and complete report Discussion Forum Interviews	**Stage Five Plan of Action** Students finalise all the documentation required to successfully complete the project. Discussion Forum: Students to reflect on their experience as a group

Appendix 5.1 Key areas of knowledge: Digital Society

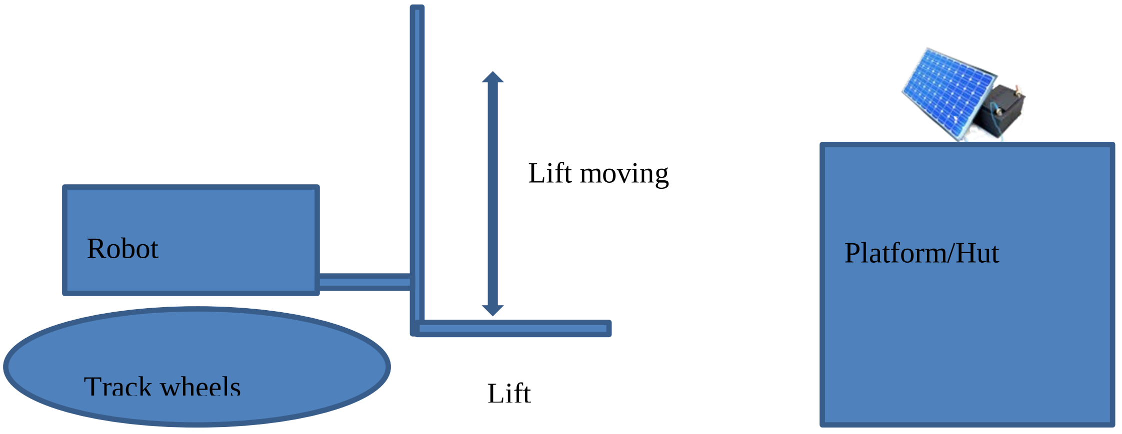
- The use of digital technologies in societal generations (generation Y and digital natives)
- Contemporary use and emerging and potential trends of digital technology in society
- Limitations and opportunities
- Legislation concerning digital technologies
- Environmental impact and health and safety
- Ethical behaviour and social contexts
- Collaborative projects – local and global interaction
- Sustainability and globalisation
- Forecast trends and new technologies
- Case studies

Appendix 5.2 Key areas of knowledge: Electronics

- Knowledge of materials and components including semiconductors
- Design, test, evaluate, repair and alter circuits and electronic systems
- Quality and reliability theory
- Signal processing (including amplification)
- AC/DC concepts
- Digital and analogue concepts (including A to D converters and logic gates)
- Telecommunications
- Microcontrollers
- Operational amplifiers
- Robotics
- Product development in industry

Appendix 5.3 Proposed Robot for Antarctic

Using the RoboCircle 3S to develop a robot that can pick up heavy "stuff" and lift it to be moved to a higher platform. Students may need to assess most of the following: interface to control lift movement, sensors to know when they reach the platform, sensors to measure overweight, counter balance requirements, power supply requirements, temperature (too hot, motors overheating or too cold (freezing). Another issue may be for students to come up with an idea to move cargo off lift.



Appendix 5.4 RoboCircle 3S educational robotic kit (CBHS version)

Inex RoboCircle with extra parts to create a track wheel robot and lift

The RoboCircle 3S is a versatile robotic kits developed by Inex Robotics. This kit consists of a microcontroller with Cricket Logo interpreter firmware with the following features:

- 4 DC motor outputs
- 4 digital inputs
- 4 analog inputs
- 2 digital outputs
- Bluetooth SSP socket
- Piezo speaker

Various mechanical bits are included:

- Plastic round base
- Two plastic grid plates
- Universal plate set
- Universal arm set
- Track and wheel set (To build a Hagglund type wheelbase)
- Nuts, bolts etc

These mechanical parts enable the creation of robots with different formats like a robot with two big round wheels, a robot with track wheels, controllable lift, weather stations, alarm systems etc. This kit also comes standard with two of each of the following sensors: infrared reflectors, light sensors, touch sensors and LED's. One infrared detector is included.

The standard kit can be used to create various movements (depending on physical design), follow lines or detect edges and object avoidance. With the versatile inputs and outputs other add-ons can be developed like RF receivers and transmitters and thermometers or current designs can be improved. Other components can also be controlled like relays, stepper motors, LED's, LCD's etc. The interfaces are well documented and various add-on circuitries can be designed.

Appendix 5.5 Handy links

1. Virtual Cricket Logo: http://www.cs.uml.edu/ecg/projects/vcricket/ . I find this work better in Internet explorer due to Firefox's current issues with Java.
2. Logo Interpreter: http://www.calormen.com/logo/
3. The Handy Cricket: http://www.handyboard.com/cricket/
4. The Logo programming language: http://en.wikipedia.org/wiki/Logo_%28programming_language%29
5. RoboCircle curriculum
6. Jing - http://www.techsmith.com/jing.html
7. Show reflection on e-Portfolio including photos, videos

Appendix 6. Assessments

Appendix 6.1 Achievement Standard 91639

National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Internal Assessment Resource

NZQA Approved

Digital Technologies Level 3

This resource supports assessment against:

Achievement Standard 91639

Implement complex interfacing procedures in a specified electronic environment

Resource title: Develop transport robots for Antarctica

4 credits

This resource:

- Clarifies the requirements of the Standard
- Supports good assessment practice
- Should be subjected to the school's usual assessment quality assurance process
- Should be modified to make the context relevant to students in their school environment and ensure that submitted evidence is authentic

Date version published by Ministry of Education	December 2012 To support internal assessment from 2013
Quality assurance status	These materials have been quality assured by NZQA. NZQA Approved number A-A-12-2012-91639-01-6205
Authenticity of evidence	Teachers must manage authenticity for any assessment from a public source, because students may have access to the assessment schedule or student exemplar material. Using this assessment resource without modification may

	mean that students' work is not authentic. The teacher may need to change figures, measurements or data sources or set a different context or topic to be investigated or a different text to read or perform.
Date modified by [redacted]	June 2013 for different context by Katana Dunn and [redacted]

Internal Assessment Resource

Achievement Standard Digital Technologies 91639: Implement complex interfacing procedures in a specified electronic environment

Resource reference: Digital Technologies 3.48

Resource title: Develop transport robots for Antarctica

Credits: 4

Teacher guidelines

The following guidelines are supplied to enable teachers to carry out valid and consistent assessment using this internal assessment resource.

Teachers need to be very familiar with the outcome being assessed by Achievement Standard Digital Technologies 91639. The achievement criteria and the explanatory notes contain information, definitions, and requirements that are crucial when interpreting the Standard and assessing students against it.

Context/setting

This assessment activity requires the student to implement complex interfacing procedures in constructing a control system for a robot to transport and lift heavy devices in Antarctica. The environment will be provided. The focus is on a number of interfaces that are required to work in this environment.

This assessment activity could be used in conjunction with the assessment activity Digital Technologies 91640 Transport robots, to assess student work in developing a control system for this robot. This standard focuses on developing both the hardware and software aspects of the interfaces that are involved in the project, and the time spent on this task may occur in a number of segments throughout it.

You could give the students a set of specifications, and components, sensors and actuators, which they use to design and build their control system for a robot. The whole class makes similar products. The students may negotiate with the teacher whether they will use the equipment provided or make their own modifications to it. Alternatively, the students may have fully established the specifications for their outcome in prior technological practice, and are ready to make it.

In either case, before they begin to make their product ensure each student has a set of specifications for the product, and that they have access to an appropriate work environment and the tools and materials they will need to safely make their electronic environment.

You will need to conduct appropriate prior teaching and learning about the requirements and technology involved in complex interfacing procedures before students begin this assessment task. Students are expected to work with, and develop an understanding of, actuators, sensors and the programming environment in which they will work and confidence in using them. This is to prepare them adequately for this task.

Students must be able to use all machines and processes safely and in accordance with health and safety requirements.

Conditions

This is an individual task.

The credit rating of this standard indicates that the time for learning, practice and assessment should be approximately 40 hours.Students should complete all their practical work in class time.

Resource requirements

Students will need access to:

- equipment for designing and prototyping electronic circuits
- a range of sensors suitable for use in a robot and lift control system (for example, switches, LDRs and photodiodes)
- a range of output devices (for example, LEDs and geared motors)
- a micro-controller development system.

Other useful resources include:

- IR proximity sensors, DC motors, stepper and servo motors:
- Mind Kits – http://www.mindkits.co.nz
- Bright Sparks – http://www.brightsparks.org.nz/index.cfm
- Robot kits and parts - http://www.robokits.co.nz/
- Sparkfun - https://www.sparkfun.com/

Students will also need access to sites that provide information relating to the microprocessor system they are using. For example:

- Arduino microcontrollers: Mind Kits – http://www.mindkits.co.nz
- Picaxe microcontrollers: Revolution Education – http://www.rev-ed.co.uk
- LEGO Mindstorms: LEGO engineering – http://www.legoengineering.com
- Cricket Logo virtual programmer - http://www.cs.uml.edu/ecg/projects/vcricket/
- Cricket Logo information - http://handyboard.com/cricket/

Internal Assessment Resource

Achievement Standard Digital Technologies 91639: Implement complex interfacing procedures in a specified electronic environment

Resource reference: Digital Technologies 3.48

Resource title: Develop transport robots for Antarctica

Credits: 4

Achievement	Achievement with Merit	Achievement with Excellence
Implement complex interfacing procedures in a specified electronic environment.	Skilfully implement complex interfacing procedures in a specified electronic environment.	Efficiently implement complex interfacing procedures in a specified electronic environment.

Student instructions

Introduction

This assessment activity requires you to implement complex interfacing procedures in constructing a control system for a transport robot.

> Teacher note: You could adapt this activity to suit another outcome such as a conveyer sorting machine or a cable car or controlling a wind turbine.

This is an individual task.

You will have seven weeks to complete the work.

Complete all your practical work in class time.

You will be assessed on how well you implement complex interfacing procedures to construct your robot control system.

Task

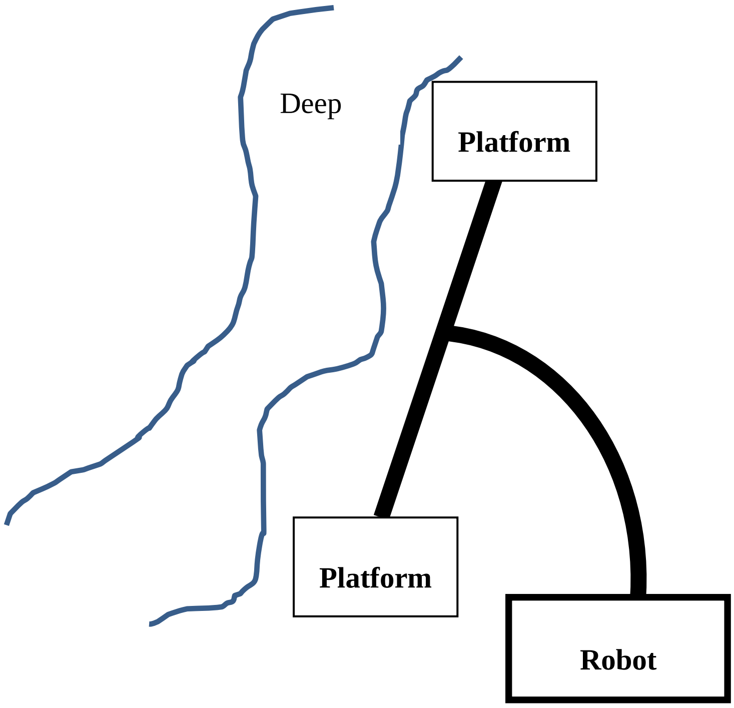
Description:

You and your team have been asked to develop a robot system to help workers in a solar farm installation project to transport and lift heavy items in Antarctica.

Construct a control system that integrates the subsystems for a robot that uses complex interfacing procedures. You are required to investigate the requirements for a robot to operate in the harsh and fragile Antarctic environment to support your specifications. Specifications are outlined below to help you in your task. Final specifications will be agreed with your teacher.

The figure below shows a description of the path and the platforms. The robot's initial position is on the "Robot Start (base)" block. Depending on an initial setting (button pressed) the robot transports its load to platform A or B. The lines are black power cables that lie on the snow to provide power to the buildings under these two platforms. The heights of these platforms are about 7 cm but you may need sensors to determine when you have reached the correct position. Automatic robot handling of the load is not required but provision need to be made for it and how it works should be explained. The robot has to return to its base. The efficient operation of the lift is more important in AS91640 although students can use bread board to build interfaces to improve the operation of the robot. This process can be used to develop the PCB's in AS91640.

Follow relevant health and safety practices in the making of your product.



Specifications

The specifications for the subsystems for the robot allow:

- a microcontroller to manage independently and reliably, variable speed, direction and power of small DC geared or stepper electric motors
- a microcontroller to interact with sensors, for example, call buttons and position sensors.

Plus additional features such as:

- following a black cable in the snow
- detect objects to ensure safe movement around the solar panel farm
- display of the lift position and worker requests using seven segment displays and/or LCDs
- sound at completion of an operation or when robot is reversing
- temperature measurements
- heater system for cold weather
- automatic maintenance alerts

- operator over-ride controls

> Teacher note: Modify the specifications so that they precisely describe the outcome required.

Note: Initial specification and designs have to be discussed and agreed with teacher before continuing.

Construct your interfaces

Construct functional models for four robot subsystems

- one to manage the motors and sensors to follow the power cable
- one to manage the motor and sensors for the lift
- one to manage the sensors that detect the platform
- one to manage worker request

Use electronic subsystems and other hardware set-ups to construct models.

Write, test, and debug software to control the subsystems and their interaction. Make sure that you:

- select the best type and value of component
- select the best arrangement of components
- modify hardware input and/or output parameters
- modify software parameters
- account for electronic noise and its filtering.

Analyse and modify your initial interfaces until they are substantially improved and you are satisfied that they perform the functions required and meet specifications (controlling the motors, detecting the position of the robot, and responding to worker requests and other sensors).

Report

As you develop, construct and interact the subsystems, record the work you are doing, including changes you have made, using photos, videos and notes and reflect on your e-Portfolio. Use these records to write a report, which you will submit as evidence for the assessment of this standard. All initial work on your e-Portfolio will be used as evidence for authenticity. Planning your initial e-Portfolio layout and continually reflecting and recording as you work on your project will minimise the amount of work needed at the end.

Show in your report how you:

- used the electronic subsystems provided to sense and interact with the environment
- used the electric motors provided so that the software on the robot can reliably vary the speed and position of the robot and the lift subsystem
- write, test, and debug well-structured, clearly annotated, readily understandable software to effectively manage the interface between the microcontroller and the sensors and actuators it controls

- analyse, test, debug and modify the functional models' sensor subsystems and actuator subsystems. This is to substantially improve the way the robot subsystems work/interact and the quality of the data delivered by the interface.

Final submission

Hand in your robot control systems, or a video of the systems interacting, and your report (If e-Portfolio can be excepted electronic submission better or students print results) .

Assessment schedule: Digital Technologies 91639 Develop transport robots for Antarctica

Evidence/Judgements for Achievement	Evidence/Judgements for Achievement with Merit	Evidence/Judgements for Achievement with Excellence
Implement complex interfacing procedures in a specified electronic environment. The student has: • devised and applied functional sensor subsystems that interact with the environment For example, the student has used a light reflecting diode to follow a black line • devised and applied functional actuator subsystems to interact with the environment For example, the student has used a bi-directional motor controller circuit to drive the motor forwards and backwards. • written software that interfaces with the data provided by the sensors and with the actuators it controls The student has written software that uses data from buttons to activate the robot and determine direction and data from the position switches to stop it • analysed modified, tested, and debugged a functional model of the interface The student will have typically made the robot operate and removed any errors, for example, following the black cable turning left or right and stop in front of the platform and return back to base. The student provides a report that accurately documents their development process, including	Skilfully implement complex interfacing procedures in a specified electronic environment. The student has: • analysed and modified sensor subsystems to improve the quality of the data delivered by the interface For example, the student has optimized the values and positions of the components used in the input circuit to improve the reliability of the detection system. • analysed and modified actuator subsystems to improve the way they work For example, the student accounts for variable loads that attain the same speeds. • written annotated, readily understandable software that interfaces with the data provided by the sensors and with the actuators it controls The student has written readable, well-formatted and annotated code (see Appendix B). • analysed, modified, tested and debugged a functional model of the interface to achieve and demonstrate improved operation For example, the student makes changes to the subsystems to improve line following techniques or the lift operation or their interaction such as lift overrride with excess load, soft start of the motor (gradual acceleration) (Some of this may be assessed in AS91640 depending on how it was	Efficiently implement complex interfacing procedures in a specified electronic environment. The student has: • analysed and modified sensor subsystems to substantially improve the quality of the data delivered by the interface For example, the student has used a frequency-modulated sensor to prevent false signals such as sunlight triggering the sensor. • analysed and modified actuator subsystems to substantially improve the way they work For example, the student has used current sensing for overload protection, which creates a response. • analysed and modified sensor subsystems to substantially improve speed and reliability of the line follow process • written well-structured, clearly annotated, readily understandable software that interfaces effectively with the data provided by the sensors and with the actuators it controls The student has written readable, well formatted and clearly annotated code (see Appendix B). An example of ‘interfaces effectively’ could be that the student has used noise reduction techniques. • analysed, modified, tested and debugged a functional model of the interface to achieve and demonstrate substantially improved operation

testing and trialling. *This description relates to only part of what is required, and is indicative only.*	implemented). The student provides a report that accurately documents their development process, including testing and trialling. *This description relates to only part of what is required, and is indicative only.*	The student will have typically made the lift operate and improved operation by, for example: – current sensing overload – seven segment LED display for, for example, floor level indication or lift coming or arrived indicator – adding sounds to indicate warnings for safety reasons – Describe options to remove heavy load and may have implemented a solution. – Using forms of environmental monitoring like temperature that control a heater for optimum operation The student provides a report that accurately documents their development process, including testing and trialling. *This description relates to only part of what is required, and is indicative only.*

Final grades will be decided using professional judgement based on a holistic examination of the evidence provided against the criteria in the Achievement Standard.

Appendix A

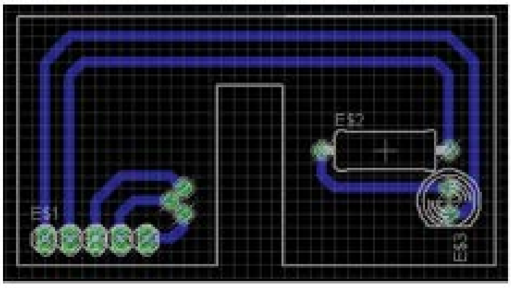
Assessment schedule appendix: Examples of sensor and actuator sub-systems

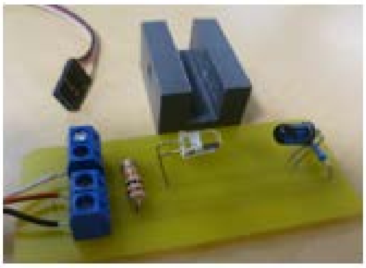
Sensor Interface

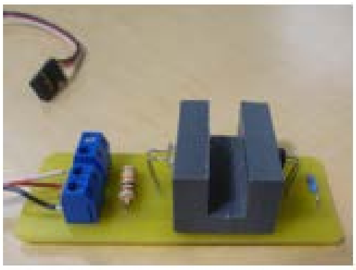
The sequence of photos below shows the software design for an optical sensing system to detect the position of an elevator in a lift shaft.

It also shows both sides of the manufactured circuit board as well as the slotted block which houses the phototransistor and the LED that are at the heart of the interface.

Also included in the photos are the connector system and the plug that allows this sensing interface to be connected to the microcontroller system.



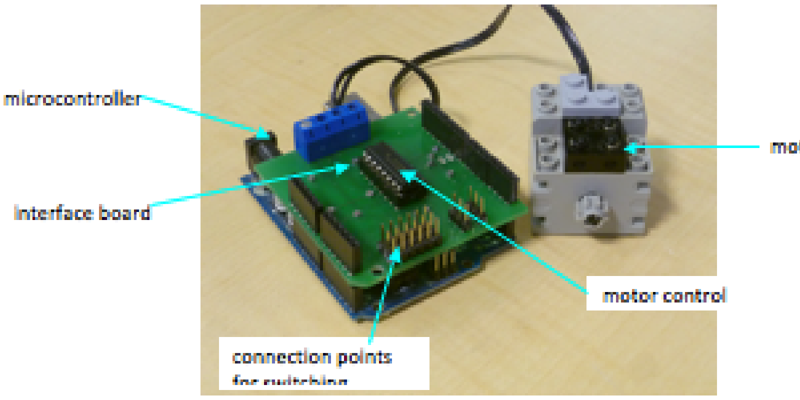




Motor Control Interface

The photo at right shows an interface board mounted on top of the microcontroller circuit board.

The main chip on the interface board is an integrated circuit that allows the motor direction and power to be controlled simply by the microcontroller.



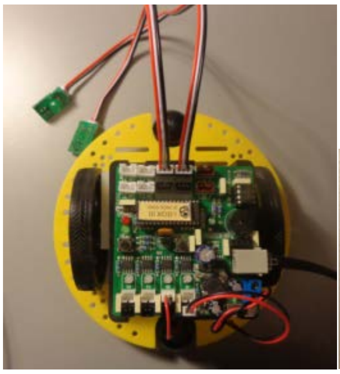
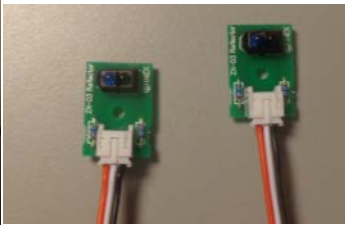
Human Interface System

The photo on the right shows the switches that the users can press to request a lift to go to the floor they are on.

They also show the red LEDs that indicate to the user that the request is being actioned.

Infrared reflectors for line following

These two photos show the iNex infrared reflector modules used with the RoboCircle. They are plugged into one of the four analog sensor ports of the RoboCircle and the microcontroller reads the “raw” values that the program needs to use as required. See code in Appendix B. The line sensors are places underneath the robot, about 5mm (height should be determined for optimum use) above the line on both sides of the black line to be valued.

Appendix B: Code snippets

The code shown in this snippet is an example of the way software is used to manage the interface hardware.

In this case, the hardware side of the interface is an integrated circuit that is capable of controlling the direction and power delivered to a motor. The software side of the interface is the code that is used to manage the integrated circuit.

The snippet below is an example of this code:

```
 void soft_start_down()                //This keeps the acceleration within an
                                       //acceptable level for passenger comfort
 {                                     //It also prevents excessive current flowing as
elevator starts up
   byte i;                             //It is a variable used to count the steps in
speeding up the motor
   elevator_down();                    //This instruction controls the direction of the
elevator motor
   for(i=15; i<11; i++)                //Gradually increases the duty cycle of the
current controller
   {                                   //in 10 increments
      digitalWrite(pwm, 10*i);         //Over a period of approximately five seconds
      delay(500);}                      //This aspect of the interface is using one of the
                                       //features of the
 }                                     //microcontroller to manage the power delivered
                                       // to the electric motor
```

This code below shows line following code implemented with Cricket Logo:

Cricket Logo Programs

```
;This code is a loop used to follow a black line using two infrared reflector sensors
; Motor a is left and motor b right
;Global variables
global [ left right ]            ; Create two global variables left and right to store sensors values

to start                         ; Start of procedure
        ab, setpower 3           ; Set motor a and be to power level 3 (Range 1 to 8)
        ab, on                   ; Turn motor a and b on
        loop [ setleft (sensor 1)        ; Set variable left to sensor 1 value
             setright (sensor 3)         ; Set variable right to sensor 3 value

             if (right > 600 and (left > 600)) ; If both left and right sensor is > 600 it sees white and do this
                [ ab, thisway            ; Go one direction
                 ab, onfor 10            ; Turn motor a and b on for 100 ms (100 = 1s)
                 beep
                 wait 10 ]               ; Wait 100ms

              if (left < 600)            ; If left sensor < 600 it sees black
                [ b, thisway             ; Go in forward direction
                 a, thatway              ; Change direction of a motor
                 ab, onfor 5 ]           ; Turn a and b motor on for 50ms

              if (right < 600)           ; If right sensor < 600 it sees black
                [ loop
                  [ a, thisway           ; Go in forward direction
                   b, thatway            ; Change direction of b motor
                   ab, onfor 5           ; Turn a and b motor on for 50ms
                   waituntil [ ((sensor 3) > 600) ]  ; Could do this to make sure robot turn until it sees white
                ]
              ]
        ]
end     ; end of procedure
```

Appendix 6.2 **Achievement Standard 91640** NZQA Approved

National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Internal Assessment Resource

Digital Technologies Level 3

This resource supports assessment against:

Achievement Standard 91640

Implement complex techniques in constructing a specified complex electronic and embedded system

Resource title: Transport Robots with lifts

4 credits

This resource:

- Clarifies the requirements of the Standard
- Supports good assessment practice
- Should be subjected to the school's usual assessment quality assurance process
- Should be modified to make the context relevant to students in their school environment and ensure that submitted evidence is authentic

Date version published by Ministry of Education	December 2012 To support internal assessment from 2013
Quality assurance status	These materials have been quality assured by NZQA. NZQA Approved number A-A-12-2012-91640-01-6206
Authenticity of evidence	Teachers must manage authenticity for any assessment from a public source, because students may have access to the assessment schedule or student exemplar material. Using this assessment resource without modification may mean that students' work is not authentic. The teacher may need to change figures, measurements or

	data sources or set a different context or topic to be investigated or a different text to read or perform.
Date modified by [redacted]	June 2013 for different context by Katana Dunn and [redacted]

Internal Assessment Resource

Achievement Standard Digital Technologies 91640: Implement complex techniques in constructing a specified complex electronic and embedded system

Resource reference: Digital Technologies 3.49

Resource title: Transport Robots with Lifts

Credits: 4

Teacher guidelines

The following guidelines are designed to ensure that teachers can carry out valid and consistent assessment using this internal assessment resource.

Teachers need to be very familiar with the outcome being assessed by Achievement Standard Digital Technologies 91640. The achievement criteria and the explanatory notes contain information, definitions, and requirements that are crucial when interpreting the Standard and assessing students against it.

Context/setting

This activity requires students to implement complex techniques to construct and test an embedded control system for managing the transport robot with lift. Students do not need to construct all mechanical parts as these can be provided. The test environment should be provided.

This assessment activity could be used in conjunction with the assessment activity in Digital Technologies 91639 Develop transport robots for Antarctica, to assess student work in developing a control system for the robot. This standard focuses on developing the monitoring and control system for both the hardware and software aspects of the robot and the functional qualities required.

The time spent on this task may occur in a number of segments throughout the project. The project itself may run for most of the school year.

You could give the students a set of specifications, which they use to design and build their control system for the robot. The whole class makes similar systems. The students may negotiate with the teacher whether they will use the equipment provided or make their own modifications to it. Alternatively, the students may have fully established the specifications for their outcome in prior technological practice and are ready to make it.

In either case, before they begin to make their system ensure each student has a set of specifications for the product, and that they have access to an appropriate work environment and the tools and materials they will need to safely make their product. The specifications need to relate to the monitoring and control of variables in both hardware and software, define the functional qualities required, and provide sufficient scope for the students to meet the requirements of the standard. Make sure that the electronic environment includes a functional combination of hardware and software.

You will need to conduct an appropriate teaching and learning programme learning before beginning this activity. Provide them with multiple opportunities to practice the complex techniques, and to become familiar with the electronic devices. Students need to be familiar with the physical, electronic, and software ranges, ratings, and interfacing techniques as well as creating their own PCB's. They need to understand the constraints when these devices are used in reactive, real time, and physical environments. Ensure they know how to write, debug, and annotate software that can manage a complex electronic and embedded system correctly.

Before commencing construction, students need to develop and confirm with you a plan that describes a sound and robust process for developing the system.

Students will need to apply testing throughout their construction process to ensure that the system is constructed accurately and meets specifications.

Conference with the students and support them as they construct their system, in case of events that may occur with the equipment or within the computer system and that are not intended to be part of the task.

Conditions

This is an individual assessment task.

Students will need three to four weeks of in-class time to complete it. Some of this is in conjunction with AS91639.

Students should complete all their practical work in class time.

Students could provide evidence across different modes. Ensure that all students have the opportunity to explain clearly why they did what they did.

Resource requirements

Materials

A simple AA battery pack powered system is recommended to keep cost and complexity to a minimum.

Other materials include:

- a microcontroller system, for example, micro controller, programming set-up, programmer, simulation software, and programming lead. The microcontroller can be any system that the school is already set up with and students are familiar with
- a prototyping system for testing, simulation, and debugging, for example, small solder-less breadboard for testing and trial programming, debugging, and/or a Kiwi-patch PCB
- a range of input sensors and devices depending on specification, for example, micro switch, LDR, Ird LED and Ird Decoder, and a phototransistor
- resistors: 470, 10k, 22k and 4M7 ohm
- capacitors: 100nF ceramic, 100uF electrolytic
- LEDs: a range of LED for use in circuits for testing and providing in circuit monitoring and indication test points
- piezo sounder to signal actions and alarm states

- a range of output devices depending on specification: P-9000 motor, Dual drive multi ratio gearbox, matching wheels, CR servo, H Bridge, and/or BC337 transistors
- PCB editing and simulation CAD software
- a matching PCB machining or etching system
- soldering equipment
- serial/LCD display to output information
- motor gearbox system, servo, stepper or a construction set that easily allows a gearing system to be included to manage the speed of the robot– this could be a construction set that includes all of the above components ready to plug and play, such as RoboCircle kits.

Other useful resources include:

- EAGLE printed circuit board design software: Cad Soft – http://www.cadsoftusa.com
- IR proximity sensors, dc motors, and servo motors: Mind Kits – http://www.mindkits.co.nz
- Bright Sparks – http://www.brightsparks.org.nz/index.cfm
- Robot kits and parts - http://www.robokits.co.nz/
- Sparkfun - https://www.sparkfun.com/
- Controlling a bipolar stepper motor using microstepping - http://www.lamja.com/?p=140

Students will also need access to sites that provide information relating to the microprocessor system they are using. For example:

- Arduino microcontrollers: Mind Kits – http://www.mindkits.co.nz
- Picaxe microcontrollers: Revolution Education – http://www.rev-ed.co.uk
- LEGO Mindstorms: LEGO engineering – http://www.legoengineering.com
- Cricket Logo virtual programmer - http://www.cs.uml.edu/ecg/projects/vcricket/
- Cricket Logo information - http://handyboard.com/cricket/

Additional information

Planning is not assessed in this standard. However, it is strongly recommended that students develop a plan to provide a framework for their project to ensure that all the necessary stages are covered and sufficient evidence is collected.

Set key milestones as break points where stages can be signed off and evidence is checked, validated, and processed. As a minimum, use a check sheet to make sure key steps have been closed out, and evidence is gathered and validated.

Suppliers of relevant materials include:

Mailtronics Ltd – www.mailtronicsnz.com

Surplustronics – www.surplustronics.co.nz

Electroflash – www.electroflash.co.nz

Internal Assessment Resource

Achievement Standard Digital Technologies 91640: Implement complex techniques in constructing a specified complex electronic and embedded system

Resource reference: Digital Technologies 3.49

Resource title: Transport robots with lifts

Credits: 4

Achievement	Achievement with Merit	Achievement with Excellence
Implement complex techniques in constructing a specified complex electronic and embedded system.	Skilfully implement complex techniques in constructing a specified complex electronic and embedded system.	Efficiently implement complex techniques in constructing a specified complex electronic and embedded system.

Student instructions

Introduction

This assessment activity requires you to plan and construct an embedded robot with lift control system that meets specifications. The same robot constructed for AS91639 Develop transport robots for Antarctica can be used. The main difference between these two standards is that AS91639 is about implementing existing subsystems whereas AS91640 is about developing complex interfaces on PCB's and use these in your robot system.

Teacher notes: *The students are not required to replace all the interface subsystems but need to have developed enough to show that various aspect of this standard has been completed to a satisfactory standard.*

Teacher note: This assessment activity is based on a robot with a lift. You could adapt it for another outcome such as a elevator, conveyer sorting machine or a cable car.

This is an individual task.

You have three to four weeks of in-class time to complete it. Some of this time is in parallel with AS91639.

Teacher note: Adapt the time allowed to meet the needs of your students.

You will be assessed on how well you implement complex techniques in constructing and testing your robot control system to meet the specifications.

You should reflect continuously on e-Portfolio in an appropriate format. This may help you to have less work to do at the end.

Task

Your teacher may provide a working mechanical model of a lift to be used with the robot parts available. Using these parts, construct a robot and lift control system that can follow a line and manages the operation of the lift to meet specifications. Before you begin construction, plan out your work, and decide how you will keep evidence throughout the project of what you did, when you did it, how it worked, and how you addressed problems. You will not be assessed on your planning.

Comply with relevant codes of practice, including health and safety regulations, in all your work.

Specifications

The robot needs to:

- Move to appropriate platform depending on operator input and return to base
- Control lift to move between ground level and platform
- Illuminate a display to indicate which platform selected
- Provide sound for safety for example when robot reverse
- Provide an indication when robot lift is in operation
- Regulate the various motor speeds for safety, efficiency, and comfort
- Incorporate extra inputs such as overload, speed regulation current sensing, fault indication, temperature sensing, automatic maintenance notifications, alarm lock-outs.
- Use various digital circuitries to make input and outputs more efficient or usable. For example as a decoder circuit to increase the number of digital outputs.

> Teacher note: Adapt these details as necessary so that they precisely describe the specifications that your students must meet. You could require students to develop these themselves, and confirm their suitability with you.

Note: Initial specification and designs have to be discussed and agreed with teacher before continuing.

Process

Follow or adapt this process:

- confirm/agree the plan
- choose the main methods/subsystem strategy and design
- select the materials
- prototype, function test, and debug the subsystems
- record debugging code and testing results, circuits, sketches, and circuits

- put the subsystems together and confirm operability
- test, debug, fine-tune and refine circuits, PCB, and program code
- build the project
- test, prove, evaluate, report, present.

Final submission

Hand in for assessment:

- the working robot and lift with software and PCBs
- debugging and final computer code
- annotated data sheets
- annotated sketches and circuit diagrams, PCB artwork
- debugging and test results
- annotated photographs
- video of the robot and lift working
- any other evidence of the construction and testing process.

The evidence that you provide should show the following:

- the functional circuits on the PCBs must be reliable, with substantially improved track lay-out and soldering
- the embedded software must be debugged and modified with code that is in a well structured, clearly annotated, and readily understandable format
- the signal and data parameters must be analysed and effectively managed.

Assessment schedule: Digital Technologies 91640 Transport robots with lifts

Evidence/Judgements for Achievement	**Evidence/Judgements for Achievement with Merit**	**Evidence/Judgements for Achievement with Excellence**
The student has implemented complex techniques in constructing a specified complex electronic and embedded system. The student has produced a robot with lift to meet specifications with associated input and output interfacing circuits. The student has: • used PCB (printed circuit board) CAD software to develop a PCB layout that will preserve signal integrity PCB's is functional and the robot operates as intended. The quality of the PCB including soldering is to a high enough standard to ensure proper functioning. The PCB layout preserves signal integrity. *For example, by separating input and output tracks and board layout and arrangement.* • constructed, tested, analysed, and modified functional circuits on PCBs The student has built and tested the circuits for the subsystems, correcting where necessary. *Evidence is produced of functional testing of the circuits and overall project, for example:* – *testing of the inputs and outputs of each subsystem* – *there is logical response of the motor and LEDs to the call buttons and position switches* – *speed control performs correctly.* • written and debugged software that can manage a complex electronic and embedded system	The student has skillfully implemented complex techniques in constructing a specified complex electronic and embedded system. The student has produced a robot to meet specifications with associated input and output interfacing circuits. The student has: • constructed, tested, analysed and modified reliable circuits on PCB, with improved track layout and soldering The PCB layout is improved, for example, by: – using a number of PCBs – matching PCB track width to signal, power outputs, and power DC rails – taking care with track spacing and location – correctly dimensioning components to fit PCB neatly – clean and tidy soldering of PCB with smooth secure soldered connections – organised and secured wire runs to sensors and motors. • written, debugged and annotated readily understandable software that can manage a complex electronic and embedded system The student has written readable, well-formatted, and clearly annotated code The student has tested and debugged the program to ensure that it functions correctly	The student has efficiently implemented complex techniques in constructing a specified complex electronic and embedded system. The student has produced a lift to meet specifications with associated input and output interfacing circuits. The student has: • constructed, tested, analysed and modified reliable functional circuits on PCB, with substantially improved track layout and soldering The PCB layout is substantially improved, for example, by: – *using double-sided PCB with ground plane* – *using surface mount devices (SMD)* – *using connector plugs, header strips, ribbon cables.* Software is well structured and documented. Extended commands have been used. • written, debugged and modified well-structured, clearly annotated, and readily understandable embedded software The student has written readable, well-formatted, and clearly annotated code. *For example:* – *several versions of the program have been developed* – *effective use has been made of macros, subroutines, library functions (such as motor speed control, library call)*

The student has written and debugged the code to ensure that the robot functions as intended. • analysed and managed signal and data parameters The student will have considered how the robot responds to buttons pressed while considering its present position (such as at platform or busy line following). *For example, requirements for trapping and storing multiple input data while in transit.* *This description relates to only part of what is required, and is indicative only*.	and as intended on a sample of expected operating conditions. *For example, multiple calls, overload, and the sequence it generates in response to button activation.* • analysed and improved management of signal and data parameters *For example, multiple button presses to show which platform, lift overload, and the actions generated in response to these conditions.* *For example, with overload issues, if the lift is going to be overloaded the student will analyse the readings from the overload sensors to determine the difference between average and overload conditions. The student will then set operating limits or thresholds to function as specified.* *This description relates to only part of what is required, and is indicative only.*	– *calls to subroutines, library linked code that communicate with advanced digital sensors using I2C and specialised digital formats* – *macros or subroutines are used to scale values, store data, and transmit data to local LCD or remote digital monitoring and debugging systems.* • analysed and effectively managed signal and data parameters Software techniques such as averaging, dynamic thresholds are used to overcome problems such as noisy, fluctuating signals, 50Hz light flicker, contact bounce etc. *For example, the student analysed the readings from the overload sensor using debug or serial text to determine the difference between a normal operating load and an overload. They then built thresholds into their programme to allow for safe operating.* *The student checked that the programme was monitoring the limit switch often enough to guarantee detection of the elevator.* *The student used averaging to improve reliability of the line following code.* *This description relates to only part of what is required, and is indicative only.*

Final grades will be decided using professional judgement based on a holistic examination of the evidence provided against the criteria in the Achievement Standard.

Appendix 7. Questions for Interviews

As a general outline these would be the type of questions to start with:

- Why have you taken this subject?
- What is your interest in robotics or electronics?
- What did you expect from this course?
- How are you doing in the other subjects?
- Why didn't you go on Moodle a minimum of 4 times a week? Easy access?
- Have you received the e-mails I sent to you?
- Do you think changing teachers was a problem for you?
- How did you find the two classes?
- How do you spend your time outside class?
- Is hands-on better for you?
- How easy was it to interact online?
- How do you feel about an online course
- Do you think this type of course can help you learn?
- Do you think it would have been easier working online if you have been doing it for a while?

Further questions will emerge from the students' responses and reflections to these interview questions. Areas to explore will be how student feel about ease of access to the course, how they felt about the interaction with the teachers, peers and the online course and their views on the learning activities provided.

Appendix 8. Electronics Course Plan

YEAR PLANNER 2013 Subject: Electronics Technology Year: 13 Level: Three

Term 1

Week	1	2	3	4	5	6	7	8	9	10	11	12
Start	28th Jan	4th Feb	11th Feb	18th Feb	25th Feb	4th March	11th March	18th March	25th March	1st April	8th April	15th April
End	1st Feb	8th Feb	15th Feb	22nd Feb	1st March	8th March	15th March	22nd March	29th March	5th April	12th April	19th April

Introductory Electronics | Bionics: Analogue and Digital Systems

Term 2

Week	1	2	3	4	5	6	7	8	9	10
Start	6th May	13th May	20th May	27th May	3rd June	10th June	17th June	24th June	1st July	8th July
End	10th May	17th May	24th may	31st May	7th June	14th June	21st June	28th June	5th July	12th July

Antarctic Robot

Term 3

Week	1	2	3	4	5	6	7	8	9
Start	29th July	5th Aug	12th Aug	19th Aug	26th Aug	2nd Sept	9th Sept	16th Sept	23rd Sept
End	2nd Aug	9th Aug	16th Aug	23rd Aug	30th Aug	6th Sept	13th Sept	20th Sept	27th Sept

Rescue Robot

Term 4

Week	1	2	3	4	5	6	7	8	9
Start	14th Oct	21st Oct	28th Oct	4th Nov	11th Nov	18th Nov	25th Nov	2nd Dec	9th Dec
End	18th Oct	25th Oct	1st Nov	8th Nov	15th Nov	22nd Nov	29th Nov	6th Dec	13th Dec

Reliability and testing Electrical fault finding and

Content (Terms 1–2):

Introductory Electronics	Bionics	Antarctic Robot	
Research/investigation	Transducers	Research/investigation of issue	Binary and logic concepts
Circuit Design techniques	Sensor systems	Develop and analyse analogue and digital electronic systems	
PCB Production	Analogue circuit design	Select components and systems enabling design	
Mock-up (Eagle)	Prototyping and modifications	Construct and manipulate software to develop and control an outcome	
Basic components	Test, evaluate, refine solution.	Fault finding in circuits and/or microcontroller systems	
Bread-boarding	Develop high quality solutions	Develop high quality and reliable systems	
Circuit construction	Collate stakeholder feedback	Effectively document systems and procedures to achieve a solution	
Ergonomics	Interfaces	Digital /Analogue Concepts	A to D converters and logic gates
AC/ DC Concepts	Semiconductors	Power supplies and Motors	Operational Amplifiers
Brief development	Microcontrollers	Telecommunications	Signal Processing

Standards:

US 26120: Describe Operation of electronic devices 4 credits. Maximum Excellence

US 26119 Plan, construct, report on prototype 4 credits Max Excellence

US 26121 Modify working prototype 6 credits Max Excellence

AS 91639: Implement complex interfacing procedures in a specified electronic environment 4 credits Internal

AS 91638: Demonstrate understanding of complex concepts used in the design and construction of electronic environments 4 credits External

AS 91640 Implement complex techniques in constructing a specified complex electronic and embedded system. 4 Credits Internal

Due dates:

US 26120 Portfolio due 19th April

US 26119 Report due 12th July

US 9221 Industry visits and assessment term 4

AS 91639 Report
Due Date: 17th May

AS 91638 Report
Due date: 9th August

US 26121 Report
Due date: 27th Sept

AS 91640
Due date: 25th Oct

Term 4:

Tidy up
A.S. 91639
U.S. 26120
For moderation
US 9221 Industry Studies
Product development in industry. 3 credits

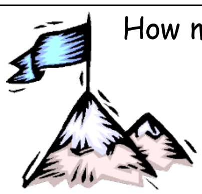
Due Date for External Moderation is 1st November

Appendix 9. Icebreaker Worksheets

Appendix 9.1 Robot Space Orienteering Sheet A

1	Create a folder called 'Robotics' in your H drive. Save this **Orienteering sheet** in your 'Robotics' folder. Key-in your answers below. Save.	
2	Look at the **"Course Menu"** on the left.	
	How many sections are in the course menu?	**Answer:**
3	Have a look at the course outline in the **Course Information** section.	
	What will you do in Week 4?	**Answer:**
4	Look in the **"Course Information"** section. *Find the link to the learning outcomes file and save this to your 'Robotics' folder. Add your name to the document. This file is used to keep a record of which learning outcomes you have completed and will be posted in your e-portfolio at the end of the course.*	
	How many Learning Outcomes are in this course?	**Answer:**
5	Look under the "**Assessment Information"** section. *This is where you will find all the information about what assessment is involved in this course, and how things will be assessed.*	
	What are the areas you will be assessed on?	**Answer:**
6	How many quizzes are there?	
	Answer:	
7	When you have completed and saved your updated version of this sheet, upload it into the "Icebreaker Forum". You can find all the forums under the **"Activities"** group on the left hand side. Don't forget to add your name in the subject line and include any experience you have with robotics.	

Appendix 9.2 Robot Space Orienteering Sheet B

1	Go to the **"General Discussion" Forum** section. This can either be found in the "**Course Information"** section or under the "**Activities"** group is a **Forums** link *This is where you can ask any questions you have about the coursework or the learning space.*
	Post a 'reply' to my post titled "**Orienteering Task**". Copy your post into the space below.
	Answer:
2	Find the file learning tools in the "**Course Information"** section.
	What type of learning tools do you think works best for you?
	Answer:
3	In the ""**Assessment Information"** open the Rubric for Participation. Name the areas that will be assessed.
	Answer:
4	Each section has this code. What type of code is it? What does it say?
	Answer:
5	 How many of these images are there and what do they mean?
	Answer:
6	When you have completed and saved your updated version of this sheet, upload it into the "Icebreaker Forum". You can find all the forums under the **"Activities"** group on the left hand side.