Science and Mathematics Education Centre

Factors that Facilitate or Impede the Effective Implementation of Open Source Software to Support Learning and Teaching in a New Zealand Senior High School

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DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgement has been made.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human ethics approval from the Curtin University Human Research Ethics Committee, Approval Number #SMEC-08-12.

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ABSTRACT

According to the literature, there is a gap between the learning style of students and the pedagogy currently used in high schools. Therefore, this case study focused on a new school that aimed to close this gap by changing pedagogy, adopting an open educational philosophy and using open source software to support learning.

This study's main focus was the factors that facilitate or impede the effective implementation of open source software to support learning and teaching in a senior high school. Subsidiary questions involved the stakeholders' views about the nature of open source software, rationales for its use in the school, its advantages and disadvantages in the educational context, and the pedagogy used in classrooms by teachers in relation to open source software. Because the literature review indicated that little research has been conducted on the use of open source software in senior high schools, this study contributes to knowledge about the use of open source software in education.

The case study included a thematic analysis lens when analysing interview and survey data. All major stakeholders, including the Board of Trustees, senior management, teachers and students, were asked for their opinions about the use of open source software for learning and teaching within the school. Interview and survey data were coded to generate common themes that are reported in the results chapter and considered further in the discussion chapter.

Analysis of responses showed that open source software was used to scaffold learning in specialist subject areas of the curriculum. The main advantage of open source software was considered to be its provision of equitable access to all students in the school to specialist educational software to scaffold their learning. However, open source software was identified as one component of a mixture of software used by teachers and students in the school. Cloud-based software such as Google Apps for Education and social networking software played an equally important role in the school's open connectivist learning. The school had a unique open educational culture that included open teaching spaces, open educational resources and an inquiry-based programme that gave students a choice of projects.

This research confirmed the importance of digital tools for scaffolding learning in a high school that provides a mixture of software for students, as well as highlighting the increasing importance of cloud-based software and social networking software to support constructivist and connectivist learning on the network for high school students who are using their own devices.

The major factors identified were *people* (learning vision and open educational culture), *pedagogy* (constructivism and connectivism to accompany learners, nurture and bring learning to life) and *digital tools* (choice, access and a mixture of software available for learning) to learn within a community-of-practice in the senior high school. Open source software is a component of a software mix, which allows equitable access, sustainability, adaptability and cost-saving in a school where digital tools support the people and pedagogy in achieving school goals.

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LIST OF ACRONYMS

Acronym	Meaning
ICT	Information Communication Technology
OSS	Open Source Software
SMS	Student Management System
TED	Technology Entertainment Design
ERO	Education Review Office
NMC	New Media Consortium
NTHS	New Technology High School
PISA	Programme for International Assessment
FOSS	Free Open Source Software
FLOSS	Free Libre Open Source Software
COSS	Commercial Open Source Software
GNU	GNU is not Unix!
UNIX	UNiplexed Information and Computing System
GPL	General Public Licence
RAM	Random Access Memory
GIMP	GNU Image Manipulation Program
PDF	Portable Document Format
MCHS	Michigan City High School
(inACCESS)	Indiana Affordable Classroom Computers for Every Secondary Student
IT	Information Technology
ASHS	Albany Senior High School
OER	Open Educational Resource
ZPD	Zone of Proximal Development
MOODLE	Modular Object-Orientated Dynamic Learning Environment
E-PORTFOLIO	Electronic Portfolio
CoP	Community of Practice
WINTEC	Waikato Institute of Technology
NZSTA	New Zealand School Trustee Association
BOT	Board of Trustees
DP	Deputy Principal
BYOD	Bring Your Own Device
PLC	Programmable Logic Controller
WINE	WINE is not an Emulator
SaaS	Software as a Service
PHP	Hypertext Pre-Processor
CAD	Computer Aided Design
HTML	Hypertext Markup Language
MySQL	My Structured Query Language
NCEA	National Certificate in Educational Achievement
CV	Curriculum Vitae
LMS	Learning Management System
ODF	Open Document Format
GAFE	Google Apps for Education
SIIA	Software and Information Industry Association
RTF	Rich Text Format
PC	Personal Computer
NPDL	New Pedagogies for Deep Learning
COW	Computer On Wheels
RTF	Rich Text Format
ODT	Open Document Transfer

Chapter 1

THESIS INTRODUCTION

1.1 Chapter Introduction

The spark for this research was the researcher's attendance at a national ICT education conference where a presentation (Osborne, 2009) was given on the role of open source software in a newly-opened senior high school. Open source software is used throughout that school both for administration and learning. Following the presentation, I reflected upon the role of open source software for both learning and teaching.

1.1.1 Albany Senior High School

Albany Senior High School

By Mosborne01 - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/wiki/File:Albany_Senior_High_School.jpg#/media/File:Albany_Senior_High_School.jpg

Albany Senior High School was opened in 2009 and is New Zealand's first state-funded senior high school (Wikipedia, 2021a). A state-funded school is a public school that all students from the local area can attend at no cost. This school was designed from the beginning as a modern learning environment. A senior high school caters for students in Years 11 to 13 (ages 14 to 18 years). The Educational Review Office (2019) reports that the school is a large suburban school of 800 students in Years 11–13. The school's learning environment is innovative and well designed. Wikipedia (2021a) describes how all classes take place in large open areas called 'learning commons'. The learning commons enable flexibility when planning and delivering classes. All students have easy access to technology from computer pods or BYOD (Bring your own devices) and open access to the school computer network. Students are encouraged to use their devices in class to collaborate, share and cooperate on Google Workspaces for Education. The senior high school website states that "the vision is to nurture, inspire and empower each other. To achieve highly and become good citizens" (Albany Senior High School, n.d.-b, para. 1)

Learning Commons at Albany Senior High School

Being a new school with no traditions, the senior high school is in a unique position to introduce innovative teaching pedagogies infused with ICT (open source derived) to enhance learning. The senior high school is unique in a number of ways (Albany Senior High School, n.d.-b) Wikipedia (2021a, para. 7) states "from 2009 to 2019 Albany Senior High School's computer network, desktops and staff laptops ran almost entirely on open source software". Wikipedia (2021a) also describes the student-centred inquiry programme that runs every Wednesday and allows students to engage in a community-based inquiry project either in a team or individually.

This case study was conducted in this senior high school, that utilises innovative teaching pedagogy infused with open source software, to identify and analyse factors that facilitate or impede the implementation of open source software. The school's uniqueness made it a timely focus for research into open source software for learning that could guide other schools. However generalising findings to different senior high schools and social-economic status might be limited because of limited access to devices and software.

1.1.2 Open source software

Opensource.com (n.d., para. 3) defines open source software (OSS) as "software with source code that anyone can inspect, modify and enhance". In contrast, proprietary software's source code is hidden and modification is prohibited. When using open source software, users must accept the terms of the open source licence which enables people to "use, study, modify and distribute software" (Opensource.com, n.d., para. 9).

For the senior high school, this means that the school can run any open source software on the school computers and distribute the software to students to use on their personal computers. The school can also adapt and customise any software as required. The open source software can then be shared with any other schools, organisations or individuals wishing to use the improved open source software. The school is free to use, adapt and distribute open source software. The challenge for the school is to locate software that is suitable for teaching and administration needs. The only exception is the student management system (SMS) that comes from a proprietary source because an open source alternative has not been located. Cost saving is also an advantage for schools because they do not have to purchase educational software (Lin & Zini, 2006).

1.1.3 Specific open source software

The senior high school uses a variety of open source software on the school network available for both students and teachers. Edubuntu is used throughout the school as the base operating system. Moodle is used as the Learning Management System, while the New Zealand-developed software Koha is used as the library database. The New Zealand-developed Mahara is used as the ePortfolio software. Osborne and Tucker (2010) list three programmes that have been developed by students for use within the school, namely, microblogging, bookmarking and a digital signage tool. Email is provided by Google and all students and staff have access to G-Suite, a set of cloud-based productivity tools (Google, n.d.-b). Other specific open source software is provided depending on the application. Osborne and Tucker (2010) also note that very little professional development is needed with the open source software because it is very intuitive.

1.2 Rationale for Study

Literature (Fullan & Langworthy, 2013; Gilbert, 2005) suggests that there is a gap between the learning styles of students in high schools and the pedagogy being used currently. This case study focused on a new school that aimed to close the gap by changing the pedagogy and building architecture and using open source software to support the learning process.

1.3 Theoretical Framework

Northcentral University (2021, para. 1) suggests that the purpose of theoretical frameworks is to “provide a particular perspective, or lens, through which to examine a topic”. My position as a researcher is as a relativist who believes that all phenomena are confined to our mind and must be observed (Cohen, Manion, & Morrison, 2007) and therefore my approach was to “seek to establish the meaning of a phenomenon from the views of the participants” (Creswell, 2003, p. 20).

Regarding epistemology, my position is that of a constructivist for whom knowledge is socially constructed. J.W. Creswell and J.D. Creswell (2018, p. 8) note that: “Social constructivists believe that individuals seek understanding of the world in which they live and work. Individuals develop subjective meanings of their experiences”. I acknowledge my background as a primary-school teacher and tertiary lecturer and researcher in the field of the integration of ICT into education.

1.3.1 Constructivism/constructionism

Both constructivism and constructionism are important when defining the theoretical framework of this thesis. Crotty (1998, p. 58) defines constructivism as “the meaning-making activity of the individual mind” and constructionism as “the collective generation [and transmission] of meaning”. Constructivist knowledge claims are based on multiple meanings of individual experiences and social constructions, with an intent on developing a theory (J.W. Creswell & J.D. Creswell, 2018). Flick (2009, p. 67) notes that, with constructionism, “experiences are structured and understood through concepts and contexts, which are constructed by the subject” in the context of a case study. In this research, the experiences of stakeholders were constructed into concepts by the researcher.

The aim of constructionism is defined by Crotty (1998, p. 42):

> *It is the view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world and developed and transmitted within an essentially social context.*

Within the context of the study, I acknowledge that I bring my personal values and experiences into the inquiry. From a constructivist position, my aim is to “seek understanding of the world in which they live and work” (J.W. Creswell & J.D. Creswell, 2018, p. 8). The case study involved the stakeholders’ perspective and context.

As a qualitative researcher, I was focused on the context of the study and gathering participant-generated meanings from the stakeholders within the school community. J.W. Creswell and J.D Creswell also note that the researcher’s goal is to “rely as much as possible on the participants’ views of the situation being studied” (2018, p.

8) All stakeholders within the school were interviewed to get multiple participant perspectives of the phenomena being researched.

1.3.2 Social and historical construction

In seeking meaning through constructionism/constructivism, the researcher needs to take into account the social and historical construction of the case (Creswell, 2003). Meanings are "formed through interaction with others and through historical and cultural norms that operate in individuals' lives" (Creswell, 2003, p. 8). A school environment is a complex community where many factors and experiences affecting stakeholders need to be taken into account in the research process.

I acknowledge that meanings are formed through individuals' interactions with others in a social context (J.W. Creswell & J.D Creswell, 2018). Because learning in a school is not an isolated activity, the social context is an important factor in the research framework.

1.3.3 Theory generation

Crotty (1998) asserts that "the basic generation of meaning is always social, arising in and out of interaction with a social community" (as cited in Creswell, 2003, p. 9). From analysis of data from the school community, meanings were generated and discussed in relation to the research questions. Crotty (1998) also stated that "qualitative research is largely inductive, with the inquirer generating meaning from the data collected in the field" (as cited in Creswell, 2003, p. 9). Theories are generated from data collected from stakeholders in order to answer and analyse research questions.

1.4 Research Questions and Intentions

In this research, I identified and explored factors that facilitate or impede the implementation of open source software in a senior high school. In particular, I focused on the use of open source software to engage, create, communicate and contribute to high-order learning. Factors that combine to foster a 21st Century learning community that meets the needs of digital learners were identified. Such a study is likely to give insights into the workings of a senior high school using open source software. From these findings, a model of a senior high school using open source software was developed.

My main research question focused on the factors that facilitate or impede the effective implementation of open source software to support learning and teaching in a senior high school. This main research question led to four subsidiary research questions.

1. What do stakeholders perceive open source software to be?
2. What do stakeholders perceive are the rationales for the use of open source software?
3. What do stakeholders perceive are the advantages and disadvantages of open source software in the educational context?
4. What do stakeholders perceive is the pedagogy used in classrooms by teachers in relation to open source software?

1.5 Research Methods

This section describes the methods used for inquiring into the research question. Merriam (2009, p. 13) states that qualitative researchers are "interested in understanding the meaning people have constructed, that is, how people make sense of their world and the experiences that they have had with the world" (as cited in Guest, Namely, & Mitchell, 2013, p. 2). A simpler definition is provided by Nkwi, Nyamongo & Ryan (2001, p. 1): "Qualitative research involves any research that uses data that do not indicate ordinal values" (as cited in Guest, Namely, & Mitchell, 2013, p. 3). Qualitative research involves understanding people and meanings.

1.5.1 Qualitative research methods

A combination of case-study methods and thematic analysis was used in this study. The case-study method was chosen to give the researcher "in-depth insights into participants' lived experiences within this particular context" (Hamilton, 2011, para. 2). Initially, the case-study methods were used to investigate the research questions but, during the research process, the researcher became aware that the thematic analysis approach was more appropriate for exploring the research questions. Thematic analysis allows themes and concepts to emerge from the data. Themes are constructed from the data (Braun & Clarke, 2006). This gave the researcher the flexibility to examine the pedagogical effects of the use of open source software in the senior high school.

1.5.2 Case-study methods

Initially, the researcher used the case-study method. Stake (1995) defines a case study as being when a researcher "explores in depth an activity or one or more individuals" (as cited in Creswell, 2003, p. 15). Stake (1995) also stated that: "The case(s) are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time" (as cited in Creswell, 2003, p. 15). Patton (2015, p. 260) added that "the variety of approaches to defining a case gives you an opportunity and responsibility to define what a case is within the context of your field and focus of inquiry".

The case study involved collecting data from the senior high school that was unique because of its exclusive use of open source software. My research was focused on exploring the uniqueness.

1.5.3 Thematic Analysis

Braun and Clarke (2006) defined thematic analysis (TA) as a method for identifying themes and patterns of meaning across a dataset in relation to a research question. Peterson (2017, p. 1) states that, "at its most fundamental level, thematic analysis involves immersing oneself in the data in order to identify common ideas or themes that emerge based on the phenomenon under investigation and resonate with the research questions posed in the study". Braun and Clarke (2013, p. 175) explain that TA "aims to generate an analysis from the bottom (the data) up; analysis is not shaped by existing theory (but analysis is always sharped to some extent by the researcher's standpoint, disciplinary knowledge and epistemology"). A strength of thematic analysis method is flexibility in that it can be used to answer all kinds of research questions and analyse all kinds of data (Braun & Clarke, 2013).

My intention was to develop models of pedagogy used at the senior high school while using open source software to support learning. The roles of the students also were defined. Thematic analysis was used to understand the role of open source software (and other ICTs) within the school. Thematic analysis enabled the identification and description of implicit and explicit ideas within the data (themes) to answer the research questions (Guest et al., 2013). Terry and Hayfield (2021, p. 3) conclude that TA "is viewed as a rigorous, powerful and yet straightforward way of engaging with qualitative data".

Thematic analysis showed how the role of ICTs in supporting learning was influenced by the use of open source software and other ICTs to support learning within the senior high school.

1.6 Significance of Study

After an extensive search, few senior high schools were found to use open source software. Using open source software seems to be unique to this school. A study by Lin and Zini (2006) found that open source software "contributes to mutual and collaborative learning in an educational environment" (p. 1). During this study, the collaborative learning environment was investigated. Lin and Zini (2006) also found that students adapted very quickly to using the new software, while some of the teachers resisted its use.

Osborne and Tucker's (2010) case study on the wiki on the WikiEducator site describes the rationale and ways in which open source software is used throughout a senior high school. The senior high school's vision includes an open philosophy to only use open source software. The provision of e-learning in the school is linked to the senior high schools' vision of nurturing, inspiring and empowering student learning (Albany Senior High School n.d.-h). Osborne and Tucker (2010) have stated that using open source software allows students to install the software on any device and have access at any time in any place.

When the case-study senior high school was opened in 2009, it was in a unique position to design the information technology infrastructure from scratch in conjunction with other factors, such as building design, classroom structure, intended teaching pedagogy and overall school structure/organisation. Osborne and Tucker (2010) commented on the importance of factors such as sustainability, usability and interoperability when designing the information system for the senior high school. Osborne and Tucker (2010) also planning, savings, infrastructure, training, software and evaluation as rationales for using open source software within the school.

The results from this research are likely to be a benefit to the national and international education community. We are on the cusp of educational change and schools and the community are seeking alternative methods of teaching to prepare students for a world that we cannot anticipate. This research is likely to inform the case-study school about the ways in which open source software is being currently used from an independent perspective, as well as suggesting alternative ways in which the open source software can be used. Open source software is part of the open education culture of the school and this was examined as part of the case study.

Because a literature revealed a lack of research into the use of open source software in education both nationally and internationally, this thesis is likely to make an important contribution to the educational field. This research identified the advantages and disadvantages of using open source software for education, therefore allowing schools to make an informed decision when choosing software to support learning.

In summary, this research is likely to contribute of an understanding of the role of open source software in supporting learning in a senior high school and the pedagogy/environment required to develop independent, creative, resilient learners.

1.7 Overview of Thesis

Chapter 1 provides an introduction including background information about the case-study school, open source software and the context for the study. The rationale for the study is explained and the theoretical framework is linked to the research methods. The research questions are stated and the significance of the study is explained.

Chapter 2 provides a review of the literature concerning the use of open source software in education. Key concepts are identified and past research on open source software use in education is evaluated. The main questions and problems associated with the use of open source software in education are identified. The main issues and debates around the implementation of open source software in schools are evaluated in the light of the research available. The concept of 'openness' in education is explored in relation to resources and pedagogy.

Chapter 3 outlines the research methods used in this study of the factors that facilitated or impeded the implementation of open source software in the senior high school. Data were collected from face-to-face interviews, focus-group interviews and a web survey of students. Both case-study and thematic analysis methods were used in the research process. During the thematic analysis, theories were generated to make sense of the role of open source software in learning. Each research question was analysed using the ground theory method. The research methodology can be summarised as a case-study approach through a thematic analysis lens.

Chapter 4 reports results for feedback collected from stakeholders regarding factors in the implementation of open source software in a senior high school. Findings are presented in Chapter 4 for each research question. The views of the different stakeholders interviewed and surveyed are reported and analysed in the context of qualitative analysis. This chapter works sequentially through the research questions which guided this research.

Chapter 5 discusses the results for the research questions. The meaning and importance of the findings concerning open source software in education are explained. The results are compared with the current literature. Patterns, principles and relationships are discussed for the major findings. Suggestions are made for additional research to further understanding of the use of open source software in high schools.

Chapter 5 outlines and discusses the emerging factors that facilitated or impeded the use of open source software to enhance learning and teaching in the senior high school. The chapter concludes with the development of a model of a 21st Century senior high school using open source software to enhance learning and teaching.

Chapter 5 then reaches a final judgement about the use of open source software to enhance learning and teaching in a senior high school. The implications of software use in schools are discussed. Recommendations for further research and the future of open source software in education are made. Chapter 5 concludes with a statement about the role of open source software in schools.

The following chapter reviews literature relevant to the research.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature concerning the implementation of open source software (OSS) in supporting learning and teaching in a senior high school. Information Communication Technologies (ICTs) have promised much in transforming education but have largely failed to deliver (Cuban, 2001; Fullan, 2020; Laurillard, 2008; Robinson, 2020). Global issues such as climate change and the Covid-19 pandemic highlight the need for education to equip learners to cope with future challenges in society (Bourn, 2021; Popa, 2020; Robinson, 2020). This review focuses initially on the role of ICT in educational change and defining OSS in the educational context. OSS case studies are reviewed along with the role of OSS in educational context. Community of practice, learning theory and the digital divide are also discussed in relation to the role of OSS in education. Finally, how this study addressed a gap in the literature is considered.

2.2 Innovation and Change in Schools

Much has been written about the need for schools and school systems to change in response to the introduction of Information Communication Technologies (ICTs) and the considerable changes which society has undergone in recent years. However, many schools have failed to change despite calls by many educators. Laurillard (2008, p. 1) stated that “education is on the brink of being transformed through learning technologies; however it has been on that brink for some decades now”. Fisher (2021, p. 9) claims: “whilst there have been many explorative innovations over that time, very few have been scalable and sufficiently resilient to dislodge the primordial hold that that industrial age classroom has taken in school design for over a century.”

Pearlman (2009, p. 14) wryly asks “Hasn’t it been long enough? Nearly 100 years of public mass education, nearly ten years into the new century, you still see the 30-

student same look classrooms with students sitting in rows and columns listening to teachers and doing monotonous worksheets.” Mattila and Miettuen (n.d., p. 1) discuss the need for change in education: “The world around us has changed. At the same time, classrooms have changed relatively little in the last 100 years. The pedagogy of the classroom has stayed more or less the same for decades, offering a stark contrast to the rate of change in other fields.” Mattila and Miettunen (n.d) also discuss the opportunity to change by using the technology that young learners are already using and integrating it into the learning setting.

In an article on Making 21st Century Schools, Pearlman (2009) argued that a new culture must be established in the new schools. Model schools, such as the New Technology High School in Napa, California, were established. People were invited to tour these schools in which the students work in innovative workspaces where learning is facilitated by the use of technology.

My study involved a school which is designed to meet the needs of the 21st Century digital learner. In the following section, I review literature about the need for innovation and change in the school system.

The K–12 Horizon Report (Johnston, Smith, Levine, & Haywood, 2011, pp. 4-5) has identified five key trends that will affect learning and teaching from 2011–2016: The Horizon Report, Educause (2022, para. 1): “profiles the trends and key technologies and practices shaping the future of teaching and learning. It is based on the perspectives and expertise of a global panel of leaders across the education landscape.”

1. *“Abundance of resources and relationships made easily accessible via the Internet are increasingly challenging us to revisit our roles as educators.*
2. *As Information Technology support becomes more decentralised, the technologies are less frequently based on school servers, but in the cloud.*
3. *Technology continues to profoundly affect the way in which we work, collaborate, communicate and succeed.*
4. *People expect to be able to work, learn and study whenever and wherever they want.*
5. *The perceived value of innovation and creativity is increasing.”*

The trends identified included an increase in the importance of the broadband network to connect schools to the world and resources. The key to using the internet is to change the role of learners so that they are not just soaking up information from the internet, but using the information to create knowledge. Cloud computing is defined by Mell and Grance (2011, para. 1) as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources". With an increase in the role of the cloud, the actual operating system that schools use will become less important because the cloud will deliver applications. Google Docs is an example of cloud computing. Because students will be leaving school and entering careers that rely extensively on the use of technology, they should be exposed to using technology to collaborate and learn. Hipkins (2017, para. 3) explained that innovation and creativity will become more important not just in the teaching paradigm, but also when students leave school and work in careers that value creativity and innovation.

The K–12 Horizon Report (Johnston et al., 2011, pp. 5-6) identified critical challenges that will affect learning and teaching from 2011 to 2016:

1. *"Digital media literacy continues its rise in importance as a key skill in every discipline and profession.*
2. *Economic pressures and new models of education are presenting unprecedented competition to traditional models of schools.*
3. *The demand for personalised learning is not adequately supported by current technology or practices.*
4. *A key challenge is the fundamental structure of the K-12 educational establishment.*
5. *Many activities related to learning and education take place outside the walls of the classroom."*

The critical challenges identified in this K–12 Horizon report all involve changes to the way in which schools are structured and operate because digital literacy involves reading and creating digital knowledge to share with others, as well as using digital information to solve authentic problems both in a team and as an individual.

The William and Flora Hewlett Foundation (2013) whitepaper on open educational resources identified open source software as an open educational resource that increases educational capacity and enhances teaching by delivering personalised educational experiences.

The 2020 Educause Horizon Report (Brown et al., 2020) and the 2021 Educause Horizon Report (Petletier et al., 2021) identified open educational resources (OER) as having a significant impact on the future of teaching and learning. In particular, open educational resources will positively impact student learning and, importantly in the open source software context, provide support for equity and inclusion. Petletier et al. (2021) argue that open educational technologies have a major role in equity and fair practices regarding access to technology and content particularly regarding the trend to alternative pathways to education and online learning.

Robinson (n.d.) advocated innovation and change in the schooling system via the TED (Technology, Entertainment and Design) website. Robinson's talk has been viewed over 3.5 million times by people in 200 countries. Robinson (2009) stated that the present education system is based on the industrial model and this is stifling creativity and achievement with 21st Century learners. Robinson (2009) also stated that standardised testing and pressure to teach to tests are detrimental to student creativity and innovation. Robinson's (2009) suggested solution is a change in education culture so that learning is personalised and the needs of individual learner in local communities are customised. Robinson (2020) argued the educational changes brought about as a result of the Covid-19 pandemic are an opportunity to reset and change schools to reflect individual differences and promote the connectedness of humans. An open education system is needed as opposed to a closed industrialised system.

Gilbert (2005) stated that secondary schools will undergo a major change in the future to meet the needs of the Knowledge Society that will continue to develop. Gilbert (2005), like Robinson (2020), sees the industrialised model of schooling coming to an end and being replaced by a new model that meets the needs of a society that values existing knowledge and uses it to create new knowledge. Gilbert (2006, p. 4) stated that "schools will serve and function as learning brokers – matching students with whoever/whatever can best meet their learning needs".

Schools will also offer an ICT-rich environment. Many of the occupations in the future will involve manipulating knowledge to create new knowledge that will be used to improve society. Gilbert (2006) also stated that there needs to be a paradigm shift from knowledge being facts to being able to solve problems, manipulate knowledge and generate new knowledge whether individually or in a team. Students need to be able to work with digital knowledge as opposed to analogue knowledge. For this to happen, there needs to be major reform in the culture and pedagogy used in the schooling system.

Fullan (2011) argued that, for successful educational reform, the right drivers must be used. First, drivers must be centred on learning and teaching pedagogy. Secondly, drivers must use a community of practice to change the school culture. Thirdly, technology must be embedded within the learning and capture students' attention. Fourthly, drivers must comprise a coherent whole system change which is neither fragmented nor complicated. Fullan and Langworthy (2014, p. 42) state that "technology used without powerful teaching strategies does not get us very far." Fullan (2020) argued that leveraging digital technology is important in instigating educational change towards embedding a model called New Pedagogies for Deep Learning into schools. Open source software enables teachers and students equitable access to educational software for learning.

The Education Review Office (2021, para. 1) "is the New Zealand's government external evaluation agency that informs and facilitates improvement in schools". The Education Review Office (ERO, 2012) report for the Ministry of Education titled "Evaluation at a Glance: Priority Learners in New Zealand Schools" synthesises national evaluations and reports of good practice in New Zealand schools. The report identified three key issues that are facing New Zealand educational system for the future.

ERO (2012) listed the first key issue as shifting the focus to student-centred learning. "Teachers typically focus on adapting school systems, programmes and resources to meet the needs of the students" (p. 7). ERO (2012) also state that students should be included as partners in learning and work with the teacher in setting goals, achieving goals and evaluating learning.

The second key issue identified by ERO (2012) concerns implementing a responsive and rich curriculum. The New Zealand Curriculum vision is for "young people who will be confident, connected, actively involved, lifelong learners" (Ministry of Education, 2007a, p. 7). The ERO report stated that, because not all teachers have an adequate understanding of the New Zealand Curriculum document, the pedagogy is neither student centred nor personalised. This is closely linked to shifting the focus to student centred learning. The New Zealand curriculum is very open and allows teachers the freedom to implement a pedagogy that caters for individual student needs. ERO (2012, p. 13) states that "practice is not matching the rhetoric. ERO has found that some schools are not positioning students at the centre of learning and teaching."

The third key ERO (2012) issue is centred on using assessment information to know about, and plan for, student learning. The report emphasised that, in many schools, there are ineffective assessment practices which lead to teachers being unable to provide targeted learning opportunities to improve the learning of individual students. ERO (2012) also found that professional development is needed from the top down in schools in order to achieve more-effective assessment practices.

Not all innovative schools are successful. Vaughan (2002, p. 86) researched the rise and fall of Auckland Metropolitan College and stated that this school closed in 2001 because of "unreasonably low levels of student attendance plus a lack of procedures to promote high-quality staff performance". Vaughan (2002, p. 86) argues: "Metros ability to remain at the cutting edge of schooling was compromised by changes to, and gaps in, education policy, and that further research into alternative education is vital." The school did not fit the Education Review Office's perception of a successful school (Vaughan, 2002).

Wheeler (2012, p 1.) suggested that "the biggest barrier to successful adoption of new technologies lies in the minds of teachers". Wheeler (2005) previously suggested that factors such as lack of vision, resources and fear of the implications of technology also are factors which hinder effective integration of ICT into teacher pedagogy in schools.

Blannin et al. (2020) argue the need for teacher-focused research that meets the changing needs of teachers in an innovative school. Teachers need to collaborate with academics on research into innovations to maintain flexibility and change within a school. Teachers also need time for maintaining ongoing research into innovative practice.

2.3 Future of Education

Ramsey (1981) predicted that the advent of the computer age would lead to curriculum changes and a revolution in teaching methods in the New Zealand education system. Hipkins (2010) explained that the New Zealand curriculum was re-written in 2007 to reflect changes in education and society and to focus on pedagogical change. Ramsey (1981) predicted that the shift in instruction needed to be from obtaining information to interpreting and validating information. Ramsay (1981) also described the teacher’s role changing role from an information supplier to a problem setter.

The annual New Media Consortium Horizon (NMC) Reports focus on emerging technologies and their likely impact on learning and teaching in schools. The NMC Horizon Report 2011 K–12 Edition states in the executive summary that teachers need to revisit their roles as educators because of the abundance of resources and information available via the internet (Johnson, Smith, Levine, & Haywood, 2011); this is similar to what Ramsay (1981) advocated. Johnson et al. (2011) also suggested that teachers need to educate students to use technology in creative and innovative ways. Johnson et al. (2011) list the critical challenges for educators in the future as being the development of digital literacy skills among their students and the need for educational institutions to find new models of education to replace the outdated traditional model that is to deliver personalised education. *Evaluation at a glance: Priority learners in New Zealand schools* (ERO, 2012) also emphasised the need for educators to shift the focus to student-centred learning. This is also a recommendation in the NMC Horizon Report 2011 K–12 Edition (Johnson et al., 2012). In the NMC Horizon Report: 2018 Higher Education Edition, Becker, Brown, Davis, DePaul, Diaz, and Pomerantz (2018) identified innovation and collaboration as major challenges for teaching. Open educational resources including OSS were also identified as a developing teaching resource.

Johnson et al. (2012) also identified six key technologies that will influence education in the future. Because smartphones and tablets are becoming common among school students, schools need to adapt to allow these devices to be used to enhance the students' learning. Cloud computing has also made a major impact on many students, with cloud-based email accounts and the associated web 2.0 apps allowing content to be shared. The other significant technologies that are relevant to my study are the use of open content and the development of personalised learning environments. With the advent of the internet and information available in a digital format, educational content is easier to share and is available to download onto the students' mobile devices. Personalised learning environments will also be accessible via the internet. If all students are able to construct their own learning space that is related to their learning, ePortfolios have the potential to meet this need if linked with the school learning management system.

Wright (2010, p. ii), in a report on e-Learning and its implications for New Zealand schools, stated that "e-Learning and collaborative/co-constructive pedagogies appear to be linked". Wright (2010) claims that, when students learn in online environments with opportunities for peer and collaborative learning, this can lead to improved educational outcomes.

In a thought-provoking article entitled "A look at the future: Is technology the answer to education's long-term staffing problems?", Synder (2004, p. 2) stated that "adding computers to a traditional, hierarchical, authoritarian bureaucracy is as productive as adding spark plugs to a steam engine. Adding computers to a traditional, authoritarian, classroom-centred educational institution has much the same effect." Synder (2004) cited a study in South Carolina in which installing 10,000 computers in 2000 classrooms showed that most of the activity on the computers involved low-level keyboard skills and that only two students were seen using a computer creatively in a classroom. In my study, I investigated a school that attempted to match the effective use of ICT (OSS) with a new educational open model. Synder (2004) argues that, with recent technological developments such as broadband internet access, wi-fi availability, access to OSS and the use of social networking are the frameworks on which a new teaching paradigm can be built. However, Synder (2004) does not discuss what types of pedagogy or school re-organisation are needed for the new educational paradigm.

Pearlman (2009) describes 21st Century Schools as open and modern learning environments where learners and facilitators collaborate using digital tools. Watson and Reigeluth (2008) call for a Learner-Centred Paradigm of Education with changes in pedagogy, assessment and support systems. Pearlman (2009) discusses a model 21st Century New Technology High School (NTHS) situated in Napa, California. This school and the other NTHS schools throughout America are very different from traditional schools. Pearlman (2009, p. 15) observes: "Walk into a classroom at a New Technology High School and you will see what we call Students at Work. Students writing journals online, doing research on the Internet, meeting in groups to plan and make Websites and their digital media presentations, and evaluating their peers for collaboration and presentation skills." Pearlman (2009) describes the physical space in NTHS schools as different, with classrooms featuring work tables scattered throughout and every student having access to a computer. Rooms are flexible and can be arranged as needed. Also, Pearlman (2009) explains that students and teachers are now called learners and facilitators to get away from the old industrialised model. Regarding pedagogy, Pearlman (2009) states that, in NTHS schools, it is centred around project-based learning or inquiry. This is a social constructivist approach in which the student is involved in hands-on authentic learning involving collaboration with peers (Starkey, 2012) and high-level critical thinking as opposed to low-level thinking with the teacher transmission model (University of Roehampton, n.d.). Pearlman (2009) indicates that the success of project-based learning is that NTHS uses guided discovery as opposed to a hands-off approach that has failed in the past. The role of technology at the NTHS is as a tool to assist students to become producers of knowledge. Pearlman (2009) explained how technology is embedded into pedagogy and daily classroom practice.

Jabari (2011) argued that students' digital imaginations need to be engaged through a new mix of pedagogy and digital tools in schools. Jabari (2011, p. 2) stated that new conceptions of design and new practices for delivery of instruction are crucial to education and societal challenges of the twenty-first century. Appropriate use of digital technology is an enabler for change.

Laurillard (2008, p. 1), in her article "Digital technologies and their role in achieving our ambition for education", stated that "never before has there been such a clear link between the needs and requirements of education, and the capability of technology to meet them. It is time we moved education beyond the brink of being transformed, to let it become what it wants to be." As Barton and Armstrong (2003) noted: "It is about changes to the curriculum, teaching styles, organisation and support systems in schools" (as cited in Laurillard, 2008, p. 3).

Laurillard (2008, p. 8) asserts that teachers should ask: "So what can technology do for us? – rather than the more typical question What can we use technology for?" In this way, technology can become embedded in the pedagogy rather than an add-on that invariably does not last. Laurillard (2008, p. 13) argues that, because many schools are still used to the transmission model of teaching, 'tell-practice-test' technology has failed to make an impact on learning because teachers are still relying on the tell technologies (e.g. Interactive Whiteboards, Slideshows) in their teaching practice. Siemens (2005) argues that traditional learning theories do not meet the learning needs of the 21st Century learner who learns by forming connections on networks and by facilitating and maintaining network connections both within and outside the school.

Furthermore, Laurillard (2008) argues that there has been little transformation in education attributable to the influence of technologies because education is a complex system of drivers that are difficult to change, technology has changed too rapidly for education to respond, education is driven by governments and bureaucracies, and education is essentially hierarchical in structure and can only change via a top-down process.

When Lin and Bolstad (2010) surveyed a group of students from a virtual classroom environment in New Zealand in 2008–2009, they found that, "although teachers in virtual classrooms are immersed in ICT, many simply use it for uploading and downloading information and teaching in the traditional way" (p. 2). Lin and Bolstad (2010) found that, although many students were using Web 2.0 technologies such as Facebook as a part of their daily lives, they did not transfer the use the Web 2.0 technologies for learning.

Lombardi (2007) argued that authentic learning is now possible because technology can assist students in making their learning more hands-on and relevant to their needs. Lombardi (2007) discussed how the internet enables learners to engage with their learning using simulation, communication and collaborative Web 2.0 tools.

Lombardi (2007) described how a variety of student-centred learning activities enables learners to create knowledge rather than just replicate it. As an example, Lombardi (2007, p. 6) stated that "students have discovered stars overlooked by veteran researchers". Often learning activities can take place in the local environment and students can contribute to their community in a positive way. Outside the local environment, "educators can use Web-based communication tools to help students collaborate with each other, sharing and constructing knowledge" (Lombardi, 2007, p. 6).

One country that has improved the success of its schools dramatically is Finland. Hancock (2011) reports that Finland has regularly outscored other countries in the Programme for International Students Assessment (PISA). Finish students were top in Reading in 2000 and in Science in 2006. Hancock (2011 p. 2) stated: "In the 2009 PISA scores released last year, the nation came second in science, third in reading and sixth in mathematics among nearly half a million students worldwide." Sahlberg (2010) stated that, in the 1960s, the levels of educational achievement in Finland were low.

Mattila and Miettunen (n.d, p. 1.), in a report on a School of the Future programme in Oulu, Finland, noted: "Inspiration for change can be found in the passion for new technologies displayed by younger generations. The challenge is to import these technological advances into the classroom and educate teachers about the possibilities they hold". Mattilia and Miettunen (n.d.) describe a holistic approach in which physical buildings have been redesigned to allow collaborative flexible learning, the curriculum has been redesigned to focus on 21st Century skills, and students' learning environment is personalised with instant access to information using ICTs. Other than a description of the school, I cannot find any research into the effectiveness of the school. Sahlberg (2010) and OECD (2010) reported that Finland highly values teachers within its society, with teachers holding a Master's degree and having rigorous preparation in content and pedagogy. Interestingly, Finish education does not involve assessing students against standardised measures, but measures each student's individual progress and abilities. Sahlberg (2010, p. 8) sums up the success of the support for teachers as being "the development of rigorous, research-based teacher education programs. Significant financial support for teacher education and professional development. The creation of a respected profession in which teachers have considerable authority and autonomy."

In the future, schools will have to adapt in the light of major global issues such as climate change and pandemics (Robinson, 2020). Adams et al. (2018) explain that adaptive learning occurs when digital tools and systems are used to create individual learning paths for students based on their strengths, weaknesses and pace of learning. Rycoo and Winkelmann (2021) state that emerging technologies, including learning analytics, artificial intelligence, machine learning, intelligent tutors, adaptive controls and robust interactive learning content, will contribute to personalised and adaptive learning.

2.4 Brief History of Micro Computing and Education

"The start of this new era of computing can be traced back to January 1975 when Popular Electronics magazine printed details of the Altair 8800 computer using a microprocessor chip as its 'brain' (Arrow, 1985, p. 105). The first personal computers were built by hobbyists in their own time. To provide support for the microcomputer, many computer clubs were set up so that computer hobbyists could swap programs and advice on using their computers. "In early 1977, after reading about clubs being formed in the USA for this new hobby of computing, Brian Conquer called together a small group of interested people in Auckland to form a club" (Arrow, 1985, p. 107). This eventually led to the establishment of an electronic bulletin board to enable members to upload and share programs via acoustic modems. Interestingly, this led to the formation of "a large library of public domain software which is available from the club and several of its user groups" (Arrow, 1985, p. 109). This is the same concept that Open Source groups use today in sharing resources and providing a location for individuals to upload programs that they have written. Arrow (1985) stated that computers in schools would be used for skill training, games with rewards and links to mathematics activities with the LOGO program. Arrow (1985, p. 116) stated: "Properly directed, their use of computers will allow full reign of their artistic creativity in many areas we are just beginning to appreciate." Cuban (2001, p. 189) noted that, by 2001, "the overall quantities of money and time have yet to yield even modest returns or to approach what has been promised in academic achievement, creative classroom integration of technologies and transformations in teaching and learning”.

Brown (1998) linked the effective use of computers in classrooms to the presence of a good ICT-using teacher: “A clear message is taken from history: the effective use of new educational technologies depends upon wise teachers who are not afraid to take active leadership roles” (p. 3). Brown (1998), in his article titled “The use of Computers in New Zealand Schools: A Critical Review”, is critical of the Ministry of Education for not providing clear guidelines or support for schools in the early critical years of implementation of ICT in the classroom. It was a struggle financially for schools to equip themselves with computers. Little professional development on the effective use of computers was available.

Millwood (2009), in his article “A Short History Off-line”, found that the UK government, in forming the Microelectronics Education Programme in 1981, had made an accurate forecast about the likely impact of ICT on education:

> *The aim of the Programme is to help schools to prepare children for life in a society in which devices and systems based on microelectronics are commonplace and pervasive. These technologies are likely to alter the relationships between individuals and their work; and people will need to be aware that the speed of change is accelerating and that their future careers may well include many retraining stages as they adjust to new technological developments*. (Millwood, 2009, p. 10)

Millwood (2009) also stated that schools should make changes to their curriculum and pedagogy when using educational technologies and that ICTs should be used to develop independent learning and efficient use of information. Millwood (2009, p. 11) also notes that “it is a measure to how hard it is to shift the culture of schooling that even now 30 years later, relatively modest transformation has occurred”.

The era from 1990–1999 was dominated by the use of interactive multimedia in classrooms. Interactive fiction (Jones & Novak, 2016) was popular for those schools who had BBC or Acorn computers on which students played interactive adventure games and made choices which dictated what the computer characters did in order to solve a puzzle or challenge. Milwood (2009) also discusses the new tools of multimedia creation, with students using multimedia software such as Hypercard, Hyperstudio and Magpie.

Milwood (2009) also discussed the development of the MySpace social networking site that enabled young people to interact online (prior to Facebook) and the expansion of Wikipedia (which eventually led to the downfall of print-based encyclopaedias such as Britannica and CD versions such as Encarta). Roblyer et al. (2010) stated that, although many young people use Facebook in their personal lives, education faculty members in higher education used traditional technologies such as email in communicating with students. Roblyer et al. (2010) concluded that Facebook is perceived to be social rather than educational and students are more open to the idea of using it for learning than schools.

In 2020, the New Zealand Digital Technologies curriculum was introduced with the expectation that all teachers would teach about digital technologies (Education Review Office, 2020). The rationale for the digital technologies curriculum "is to ensure all students up to Year 10 experience sufficient opportunities to develop their understanding and capabilities about technologies (Education Review Office, 2020, p. 5). Up until this point, teachers' use of ICTs for teaching was voluntary. The Education Review Office (2020) research report also claimed that it is an advantage if the school is not over-reliant on a particular brand or product or device.

Pelletier et al. (2021), in the 2021 Educause Report, Teaching and learning edition, identified open educational resources (OER) as a future key technology because, during the Covid pandemic, OERs allowed students to access free or low-cost resources for their learning. Increased societal equity was argued in the report as a major advantage of OERs. During the Covid-19 pandemic, schools used the OER learning management system Moodle to teach students online during lockdown periods when they could not attend school (Quansah & Essiam, 2021).

2.5 Impact of ICT on Education

Lemke, Coughlin and Reifsneider (2009, p. 5) asserted that "the reality is that advocates have over-promised the ability of education to extract a learning return on technology investments in schools", probably because teaching pedagogy/systems have not changed enough for ICTs to make a positive difference.

The New Zealand Ministry of Education (2007a, p. 1), "ICT Resourcing Framework – Final Report", found:

- *“There are differences in the quality of ICT across the sector.*
- *The management of ICT is an issue for some schools.*
- *The use of ICT for educational purposes can be improved, and schools are under increasing pressure to increase the quantity and quality of the ICT.”*

The conclusion of the report is that a new framework for the use of ICT in schools is needed for resourcing.

When Tamim, Bernard, Borokhovski, Abrami and Schmid (2011) conducted a systematic review of 40 years of research regarding the impact of technology on learning, they concluded that technology has a significant but small to moderate effect favouring the utilisation of technology as a support for instruction. White (2012, p. 2) stated that “instructional design, pedagogy and teacher practices are important aspects of technology use but that technology is not a consistent type of intervention”. White also stated that the effect of technology was greater when ICT is used to support cognition rather than to enable access to content.

Ainley, Fraillon, Gebhartd and Schultz (2011, p. 104) conducted an extensive survey of year 6 and 10 use of ICTs in Australian schools and concluded: “Two of the challenges that concern the growing use of ICT in education, work and society are the capability to use ICT and ensuring all young students are able to benefit from ICT on an equitable basis.”

Williams’ (2016) research in New Zealand schools revealed that, while there had been an explosion of technology innovation in schools, the evaluation of the effectiveness of these innovations had been ineffective. Schools need time to evaluate technology and identify technologies that improve learning and teaching in schools.

2.6 ICT in Education

Hammond, Younie, Woollard, Cartwright and Benzie (2009, p. 9) stated: “Computers came into many schools with no clear educational rationale, and it was easy for many teachers to see them as a solution looking for a problem.” Brown (1998), in his critical review of NZ schools, highlighted the lack of direction from the Ministry of Education and the haphazard way in which computers were introduced into classrooms. Many reports regarding the place of ICT were commissioned, but few were acted upon. There was no consistent strategy applied and schools largely went alone when purchasing and using ICT equipment in classrooms.

In a study by the New Zealand Council for Educational Research (NZCER) titled "Zooming in on learning in the digital age", Bolstad, Gilbert, Vaughan, Darr, and Cooper (2006) interviewed 16 young people aged between 11 and 14 years. The aim was to find out what it meant to be a digital-age learner, differences between in-school use and out-of-school use of ICT, and implications for teaching and learning practices for the 21st century. It was found that the ICT interests and abilities of the young people varied considerably and that they were not all digital natives. Not all young people were hooked to their mobile telephones or computer gaming consoles. Many of the young people were not able to express what it is like to live in the digital age. Bolstad et al. (2006) stated that young people might have misinterpreted the aim of the project, or had difficulty with the concept of the purpose of education, or the question might have needed to be re-phrased. From this study, the challenge for schools is that not all students were digital savvy and they had very different ways of interpreting the world and living their lives.

Davis (2018) concludes that digital tools are contributing to increasing personalisation of education and the increasing influence of technology on education. Davis (2018) also states that the digital divide is increasing in society and that a robust digital infrastructure is necessary for high-quality education.

2.7 Open Source and Proprietary Software

Open Source Software has been concisely defined by Allcock, Chen, Killen and Simpson (p. 1, n.d.) "as computer software distributed under a licence that allows end-users to run the software and to modify and re-distribute the software". The term open source originated during a strategy session held in Palo Alto, California in 1998. Because Peterson was concerned that the term 'free' would appear confrontational to the business world, he came up with the more business-friendly label of 'open source' (Kavanagh, 2004; Pan & Bonk, 2007). "The term open source has since been widely adopted to mean any computer software program whose source code is free to its licensed users for use, modification and redistribution" (Pan & Bonk, 2007, p. 2). That is, a community of people can work on a source code and then resubmit the code back to a central source together with improvements (Kavanagh, 2004). Open source software is frequently referred to as OSS. "The term free software dates from 1984, when the idea and arguments for it were first published by Richard Stallman" (Kavanagh, 2004, p. 3). The 'free' refers to freedom, not a purchase. Open source software is more commonly associated with the Linux operating system, but it is also configured to run on Microsoft Windows or the Apple Mac operating system (Kananagh, 2004). Thankachan and Moore (2017, p. 187) state "in literature, the concept of Free and Open Source Software (FOSS) has been used interchangeably as Open Source Software (OSS), Free Software, and Libre Software (FLOSS). However, terms such as Freeware Software and Shareware Software do not come under the FOSS definition".

Querol (2007, p. 10) notes that there is a difference between free software and open source software: "For the Open Source movement, the issue of whether software should be open source is a practical question, not an ethical one. As one person put it: Open Source is a development methodology; free software is a social movement." Free/Open Source Software is abbreviated to FOSS (Stallman, 2021a) or FLOSS (Stallman, 2021a). The libre component of FLOSS software refers to the freedom component as opposed to free software (Stallman, 2021a).

Kavanagh (2004, p. 2) noted that "the alternatives to open source can be called proprietary software, commercial software, or, alternatively, non-open, non-free or closed software". These software typically are run on Microsoft Windows software or the Apple Mac operating system. Because commercial software companies do not release the source code, purchasers of the software are unable to modify the software in any way (Optimus Information Inc, 2015).

Rather than being open source software, freeware is either proprietary software that has been offered to entice people to purchase the full version or the software version is timed to only work for a specified time period (Querol, 2007). Public domain and shareware are free but the source code is hidden (Querol, 2007).

Hart (2003) explained the difference between OSS and proprietary software by discussing the scenario of a person in the market for a new car. The proprietary dealership offers cars that have the bonnet welded shut and gives no-one access to the engine to fix any problems. You cannot modify the car or add any accessories. You also cannot buy the car: instead, you receive a license giving you the privilege of using the car.

Hart (2003) then discusses the open source dealership which has a bigger variety of cars and the bonnets are not welded shut. In fact, the engines are free and can be replaced at any time. The owner of the car is free to customise the car and add on any accessories which must be made available free to the community. If you break down, the community will come and help you at no cost.

Open source software is typically developed by a community of programmers (Bonaccorsi & Rossi, 2002). A programmer has an idea for new software, writes the code and then posts a draft onto the internet in an open source community space. Other community programmers download the software, test it and then write modifications for any errors (bugs) that are found. “What is unique to open source is that a large pool can see the code, a method known as with enough eyeballs” (Kavanagh, 2004, p. 207). Bonaccorsi and Rossi (2002) explain how the modified software is then uploaded to a website where this is repeated many times, so that the software is tested and refined each time. In this way, the software is developed by a community of open source programmers and is continually updated and released as a new version. The software is then made available as a free download.

Kavanagh (2004, p. 203) stated that there are three models in the development process of OSS: “An individual working alone, a bazaar or large loosely knit dispersed group and a conventional collocated product team.” Red Hat is an example of a Commercial OSS (COSS) or product team for which revenue is gained from software support (Optimus Information Inc, 2015).

Pan and Bonk (2007) list advantages of open software as encouraging innovation and using the talents of many volunteer coders simultaneously to reduce the cost to the user. Disadvantages include no guarantee of quality, an immature interface and hidden costs in deploying the software in an organisation (Pan & Bonk, 2007. Optimus Information Inc, (2015) lists the advantages of proprietary software as being usability (focussed features for task), stability (long-term updates and improvements), ownership (expectations of updates) and tailored support (direct contact with supplier for problems). Optimus Information lists the disadvantages as being initial license cost, dependency (locked into one vendor because of cost) and software opacity (limited customisation of product).

Johnson (2005, p. 18) identified the following criteria for defining open source:

1. *"Free distribution – Copies of the software can be made at no cost.*
2. *Source code – The source code must be distributed with the original work, as well as all derived works.*
3. *Derived works – Modifications are allowed; however, it is not required that the derived work be subject to the same license terms as the original work.*
4. *The integrity of the Author's Source Code – Modifications to the original work can be restricted only if the distribution of patches is allowed. Derived works could be required to carry a different name or version number from the original software.*
5. *No discrimination against persons or groups – Discrimination against any person or group of persons is not allowed.*
6. *No discrimination against fields of endeavour – Restrictions preventing the use of software by a certain business or area of research are not allowed.*
7. *Distribution of licence – Any terms should apply automatically without written authorisation.*
8. *License must not be specific to a product – Rights attached to a program must not depend on that program being part of a specific software distribution.*
9. *License must not contaminate other software – Restrictions on other software distributed with the licensed software are not allowed."*

Kavangah (2004, p. 3) has listed three examples of flagship OSS:

1. *"The Apache Web server, with a growing share of 65 % of installed worldwide Web servers.*
2. *The Linux operating system, used on millions of servers, which demonstrates that no system is too large and complex to be developed as open source.*
3. *The GNU C/C++ language suite, used to build Linux, Apache and thousands of programs on almost every operating system."*

Hart (2003) noted that Linus Torvalds, a 21-year-old student in 1991, developed a UNIX-like operating system which became one of the most-prominent open source software distributions.

> *Linus posted his work on Usenet groups and slowly other people started to notice. They looked at the code and started suggesting changes and submitted*

> *patches. Linus took these ideas and put them in his project and gave credit where it was due. This process caught on like wildfire and before long there were people from all over the world helping in the process.* (p. 10)

Pan and Bonk (2007) stated that the reasons for the success of Linux is its distributed code development (continual improvement by a large developer base) and its customisation for many different applications. Linux is continually updated leading to a high-quality and stable code.

Hart (2003, p. 11) stated there are four key benefits of open source:

1. *"Open source emphasises quality.*
2. *Open source stresses flexibility.*
3. *Open source decreases development time.*
4. *Closed source is characterised as non-competitive, rather than immoral."*

Vaino and Valden, (2007) noted that Stallman and the Free Software Foundation wrote the GNU General Public License (GPL), which is at the heart of the philosophy and use of all OSS. Vainio and Vaden (2007, p. 5) stated that "the main idea of the GPL is that anyone is free to use, modify and redistribute a GPled program on the condition that the same freedom of use, modification, and redistribution is also given to the modified and redistributed program".

Polley (2007, p. 1) also reminds us that "all OSS is free to use, but only some OSS is free as in cost". All OSS distributions come with an accompanying license detailing the terms of use, with most OSS having some form of copyright. Bruyninckx, De Quidt, Feijens, Lauwers, and Verhulst (n.d., p. 17) stated: "Free Software licences guarantee that authors are always adequately recognised for their efforts, while they also guarantee that developments and improvements find their way back into the community."

OSS has made a huge impact on the internet in terms being the dominant software used on web servers and has crucial advantages over Windows-based servers (Noyes, 2010). "While OSS has significant penetration in the internet infrastructure and networked environment, progress in the desktop market has been slower to demonstrate traction" (Dravis, 2003, p. 28). By 2018, Price (n.d.) noted that Linux had dominance in educational use (chromebooks), web servers, cloud servers and mobile operating systems (android).

Comparisons of OSS and proprietary software by Trappler (2009) in Table 2.1 and by Singh et al. (2015) in Table 2.2 show that one of the main differences is cost. Stephan (2018), Becta (2005a), Optimus Information Inc (2015), Tech and Learning (2012), Nesbitt, (2014) and Osborne (2009) all cite cost as a major factor in using OSS. However, Trappler (2009) states that there are often indirect costs associated with OSS in terms of customisation and maintaining an open source network and compares the support costs for OSS and proprietary software. OSS users have the choice of using paid external support or using the open source community to solve problems. Proprietary software restricts support to the vendor because the code is hidden; the user is locked into using a vendor for support.

Table 2.1 *Comparison of open source and proprietary software for cost, licence and technical expertise (Trappler, 2009, para. 9)*

Attribute	Open Source Software (OSS)	Proprietary Software (PS)
Cost	No license fee required and upgrades also require no licence fee. Can be used on both work and home computers with no cost.	Payment is required for initial license and subsequent upgrades also require a license fee. A copy for home use also requires a licence fee. Each installation normally requires a separate licence fee.
Licence terms	Source code is open and available to all users. Concise and straightforward licence terms make compliance easier. Licence terms tend to be more neutral in terms of favouring licensor or licensee.	Source code is available only to the vendor. Lengthy and complex licence terms make compliance more difficult because of lack of understanding of licence terms.
Technical expertise required to modify	There could be a cost if programmers are employed to modify the program.	No cost as proprietary software is not able to be modified.

Table 2.2 *Summary of features of open source and proprietary software (Singh, Bansal & Jha, 2015, p. 29)*

Factor	Open Source Software	Proprietary Software
Cost	Free to download. Some expertise required to install on network and fix any problems. Software updates are free.	Cost involved to purchase license to use the software. Software upgraded by vendor.
Support	24/7 support is via online groups and websites. Quality varies between support groups and how widely software is used. No specific vendor for support. Some IT skills required.	Support is via Vendor website. Little IT skills required as problems are sorted via the proprietary software company. Email and phone support may be available.
Innovation	Innovation empowered as users have the opportunity to make changes to the software to suit the user's needs.	Users have no scope for customising software as there is no access to code. Reliant on vendor to make improvements using profits for research and development.
Usability	Open Source Software usability rating is generally low as not inspected by usability experts. User manuals are variable dependent on the user group for the software.	Proprietary software usability rating is high as usability experts are used in the design process. Comprehensive user manuals are usually provided.
Security	Because the code is inspected by many eyes the security of OSS is generally high. Security vulnerabilities are fixed quicker than proprietary software.	Proprietary software is generally very secure as it is developed in governed conditions by expert programmers.
Licenses	Copy left licence under the GNU Public Licence where the code if improved must be shared with the OSS community. Licences are free.	Payment is required for a software licence. Software companies copyright the software to protect the commercial investment.
Reliability	Open source software are considered as very reliable software especially Linux based software.	Proprietary software is reliable software. If not, it will not be commercially viable.
Flexibility	Open Source Software is very flexible as it can be customised for the user's needs. Code is open.	Users are locked into one vendor and there is no scope for customisation. Updates are at the discretion of the vendor.

Trappler also identifies user unfriendliness factor: OSS traditionally has a poor user interface, while proprietary software generally has better user interfaces. However, as OSS matures, it is becoming more user-friendly. Becta (2005a, p. 6) reported: "A study of OSS in Britain found that the open source applications were perceived to be easier and simpler to use than the proprietary equivalents." Becta (2005b) found that OSS can run on older computers, which saves schools money because of not needing to be continually upgrading their computers because of software demands. In contrast, new versions of proprietary software need modern and more-powerful computers with a better processor speed and RAM requirements.

Trappler (2009) identified that, with OSS, help is supplied at no cost, but user manuals and documentation are not supplied. The user would need to use the internet or use the help files built into the software. In contrast, proprietary software products are supplied with extensive user manuals which users have come to expect.

Verkerk (2021, p. 12) defines cloud computing as referring "predominantly to industry, including both purchased services and free storage, video and music streaming and social media data". Verkerk (2021, p. 12) states: "Most people's use of cloud computing can be classified as SaaS (Software as a Service) including email, Netflix, Facebook, Spotify, Google, Instagram, Pinterest, Microsoft and Apple software." Google Workspace for Education, Facebook, Pinterest and other cloud-based applications are used extensively by teachers and students at the case-study senior high school. Garov et al. (2018) stated that cloud computing gave students access to learning material anytime, anywhere through various types of devices, which has led to flexibility in planning and implementation of e-learning. Students were given access to knowledge in a modern, cheap and easily-accessible way. Stallman (2010) advocates that cloud computing applications are controlled by the server owner and take all freedom and control from the user. Cloud computing software is similar to proprietary software regarding ownership and freedom of use.

In summary, because both OSS, proprietary and cloud computing software have their advantages and disadvantages, it is up to the user to weigh up the relative merits of each type of software. Based on the above discussion, it can be concluded that the comparisons of OSS and proprietary software provided by Trappler (2009) in Table 2.1 and by Singh et al. (2015) in Table 2.2 some years ago are still valid today.

2.8 Open Source Software Schools: Case Studies

This section reviews OSS case studies that were identified during an internet and library search which revealed a shortage of high-quality focussed research for the combination of ‘OSS’ and ‘effective implementation in schools.’ Very few recent studies were located. There is a distinct lack of research on open source software and education.

Thankachan and Moore (2017) reported the implementation of FOSS in the Indian educational setting. The deployment of FOSS to 6 million students and 200 000 teachers is one of the largest deployments in education. That study did not report the perceptions of a sample of students or teachers. When 43 senior FOSS implementation officials were surveyed, Thankachan and Moore (2017, p. 186) reported that “lack of adequate resources to train the teachers was the single biggest challenge in the adoption of FOSS”. Challenges included creating educational content, lack of manpower, resistance to change, lack of adequate software and lack of real-time collaboration. The conditions for success of deployment of OSS into schools included empowering students and professional development on integrating IT into education instead of teaching about IT.

Pfaffman’s (2008, p. 25) article titled “Transforming high school classrooms with free/open source software: It’s time for an open source revolution” noted: “In a world where most software has restrictions on copying and use, FOSS is an anomaly, free to use and redistribute without restrictions.” Pfaffman (2008) lists Open Office, The Gimp, NVU web editing tool and PDF creator as educationally-useful software.

Moyle and Ruwoldt’s (2004, p. 2) action research entitled “What place does Open Source Software have in Australian and New Zealand schools and school jurisdictions’ ICT portfolios?”, research was principally conducted at Grant High School which is located in a large country region in South Australia. The school is trialling the use of OSS while maintaining the proprietary software within the school. Both Open Office and Microsoft Office software were included on the school desktops and a CD of Open Office was provided for school and home use by the students. When Moyle and Ruwoldt (2004) surveyed parents, students and staff about their opinions of using the OSS Open Office, parents were surprisingly very supportive of the use of a variety of OSS for developing skills. Teachers agreed with the open philosophy which the software provides while in the classroom situation, but they wanted professional development so that they could use Open Office efficiently. Moyle and Ruwoldt (2004) found that students were positive about using Open Office, being able to use the same software at school and home and not having to worry about computer viruses, and the school leadership appreciated the cost savings and the open philosophy that matches the school's learning and teaching philosophy.

Ruston (2010) published a case study of Lorien Novalis School for Rudolf Steiner Education that is "a snapshot of where we are at after 8 years of working with Open Source Community Software in our School Administration and High School" (p. 1). The choice of the OSS fits with the school teaching philosophy of freedom and ensures that students obtain a deep knowledge of using ICT in their learning. Ruston's (2010) case study details the development of the use of OSS by the school, staff and students to allow the development of student creativity, as well as the school's uses of OSS for both teaching and administrative purposes. This case study was written by the IT technician/teacher and does not involve any surveys.

Thornburg (2007) reported a series of interviews conducted with staff and students at Michigan City High School (MCHS) to introduce Linux OSS on classroom computers. "The purpose of the interviews was to get insights on technology use in these classes from the students', teachers', and staff's perspectives to assist the MCHS technology leadership in their expansion and communication of the program's benefits to others" (p. 1). When asked what operating system they were using at school, two-thirds of the students did not know that they were using Linux. Thornburg (2007) infers that students were able to adapt to the Linux operating system very easily considering that most students were using Microsoft Windows XP at home. Interviews revealed that students were very positive about the use computers at school and felt that they improved their learning experience and teachers were positive about the use of Linux in the classroom both for teaching and administration (Thornburg, 2007). Many teachers wanted training on the specific programs used on the computers, such as Moodle. Also teachers "saw the classroom computers as tools that facilitated more self-directed learning" Thornburg (2007, p. 9). This case study is a positive example of the use of OSS in a high school.

Klein (2008, p. 2) described "The Indiana Affordable Classroom Computers for Every Secondary Student (inACCESS) grant program" which placed more than 22,000 OSS workstations in 24 high schools across Indiana. Klein (2008, p. 2) notes that "acceptance among teachers and students has been high. Access to technology is starting to grab the interests of previously disengaged students. Classroom management and organisation have improved." Benefits of the program were ease of administration of computers over the networks, thus saving costs and time, low training requirements because the Linux is similar to proprietary software, students being more engaged with learning, and seamless access to the web. Using the open source learning management system Moodle improved teaching by allowing teachers to give easy access to course information, assignments and quizzes by encouraging student collaboration (Klein, 2008). The purchase price per computer has dropped from $1000 to $290, giving students more class access to computers, while the Open Office software allowed students to save documents in a Microsoft Word format so that they can be edited easily at home or school (Klein, 2008). The use of OSS was critical for achieving the aim of providing students with access to computers to support their learning in schools.

The positive results of this case study are also supported by teachers and students with anecdotal comments such as: "If someone were to invent an Engagement-o-meter, our kids would zoom off the top end, and their teachers would not be far behind" (Indiana ACCESS, n.d. p. 1). Indiana ACESS (n.d. p. 4) stated: "Approximately 18,000 students use low-cost computers and OSS. Teachers and students are actively using Moodle and Star Office and a host of other open source to reinvent the curriculum and make learning more hands-on and more effective." Similar to the Klein (2008) study, Indiana (n.d.) lacks hard evidence that learning has improved and relies on comments from students and teachers in the ACCESS schools.

Lin and Zini's (2006) research in an Italian high school focused on the implementation of Free/Libre Open Source Software which challenges the relationship between users in the schools and developers of the software. The case study used qualitative ethnographic observation and participatory action-orientated research. Lin and Zini (2006) found that, following the migration of office software in a computer lab from Microsoft Office to Open Office, teachers feared having to learn new software skills, but students had few problems with the change, which is a finding similar to Indiana ACCESS (n.d.), Klein (2008) and Thornburg (2007).

Lin and Zini (2007) also reported that the teachers and students became involved in the development of writing synonyms and antonyms for the Italian thesaurus to be packaged with the Italian version of the Open Office software. Lin and Zini concluded that the development was very successful, with students contributing material and collaborating with the developer of the thesaurus. “The creation and development of Italian OpenOffice.org thesaurus shows active cross-boundary learning and developing activities based on social networking and mutual support” (Lin & Zini, 2007, p. 7). The learning and development of the thesaurus involved a community of practice (Wenger, 2006), with the learning being authentic, active, hands-on and involving collaboration with experts external to the school (Lin & Zini, 2007).

Some students also used blogs. Lin and Zini (2007, p. 8) stated that blogs show “how students build both the learning community and their collective identity based on shared learning experiences”. In this case study, the individual student blogs were linked together in a dynamic learning community similar to those formed when developers work together in developing a Linux distribution Lin and Zini (2007). During the interactions in the blogs, there were instances of teachers using ideas from students for lesson development and collaboration between the students and teachers.

Tomazin and Gradisar (2005) researched the introduction of OSS into Slovenian primary and secondary Schools. The Slovenia Ministry of Education’s goal was to introduce OSS into schools as an alternative to proprietary software for teaching and learning, but the initial barrier to the introduction of OSS was the lack of experience. Tomazin and Gradisar (2005, p. 63) stated that the goal of the OSS project was “to integrate informational environments based on open standards and OSS into educational establishments”.

Tomazin and Gradisar (2005) found that OSS had limited use in schools and in participants’ homes. “The most important obstacle in using IT in education has proved to be the poor education teachers get in using IT. Besides that, the participants listed old or non-existent equipment in schools” (Tomazin & Gradisar, 2005, p. 68). The results of this research were similar to studies in the USA in that the "important qualities of OSS in both surveys are reliability, desired functionalities, price and interoperability" (Tomazin & Gradisar, 2005, p. 68).

Hepburn (2005, p. 1), in a journal article titled "Open Source Software and schools: New opportunities and directions, focussed on the challenges associated with expense and usage restrictions of software installed on school computers. Hepburn discussed opportunities offered by OSS, such as compatibility with Microsoft Office, decreased costs, more flexibility and the reduction in the digital divide by allowing students to use the software freely at home. Hepburn (2005) concluded that software costs are a high proportion of school budgets and that the usage of OSS allows schools to spend money in other areas. Also, at a time when hardware costs have been significantly reduced, the use of OSS allows schools to give students greater access to computers in classrooms. Regarding schools moving towards using OSS, Hepburn (2005, p. 5) stated: "One of the most impressive Canadian projects has been taking place in British Columbia's School District 73. In this project, two schools were converted completely to the OSS based on the Linux operating system, with plans to convert more schools in the future." Hepburn (2005) argues that schools need to consider OSS if a substitute can be found for proprietary software and that OSS is now mature enough to be used for classroom teaching if negative perceptions of OSS can be overcome.

Becta's (2005a, p. 1) case study of the use of Open Source Software in eight schools in the UK had the following aims:

1. *"Examine how well the OSS approach works in practically supporting delivery of the curriculum and administrative management in schools, and the degree to which OSS currently in use is effective and provides functionality to the educational user.*
2. *Compare the total cost of using OSS with the total costs of non-OSS solutions, including the hidden costs associated with using any software in schools (e.g. user self-support).*
3. *Highlight examples of successful school-based OSS implementation through case studies."*

Becta's (2005a) case study, involving interviews with senior management, teaching staff, pupils and network managers, revealed that cost saving was a major factor in using OSS for most schools, while some schools were able to extend the life of older computers by using them as 'thin clients'. Technopedia (2016, para. 1) defines a thin client as "a networked computer with few locally stored programs and a heavy dependence on network resources". Becta (2005a) reported that advantages of OSS were its flexibility and transparency, which provide students with a wider range of software.

Becta's (2005a, p. 2) case study identified the barriers for use of OSS as being "incompatibility with using some curriculum software, inability to read files created in other applications and lack of familiarity with the software and resistance to its use from teachers and pupils".

Becta (2005a) reported that only two schools used Linux exclusively on all their computers, with the rest of the schools using a mixture of Linux and Microsoft or just using Microsoft to run some OSS. Becta (2005a) noted that senior managers all stated cost as a major reason for using OSS in schools. Teachers were very positive about OSS and commented on the ease of using OSS office software and pupils liking it, although the study highlighted the need for more training to ensure that pupils were familiar with the features.

From New Zealand, I located two case studies of the adoption of OSS in a school setting. Osborne and Tucker's (2010) case study involves Albany Senior High School's (ASHS) approach to using OSS almost entirely in the school since its opening. The goal of ASHS is to provide access to a range of powerful tools on every computer and enable students to use the same software on their home computers to reduce the gap between home and school. Very little user training has been provided because the software is very user-friendly and a community of practice has developed within the school to solve common problems with the OSS. Osborne and Tucker (2010, p. 15) conclude that "Albany Senior High School values openness, transparency and collaboration in learning, which makes Open Educational Resources (OER) and free software a perfect fit".

A case study of Warrington School (n.d.) outlines the rationale for and use of OSS in a New Zealand primary school. This school follows an open education philosophy and the OSS fits in well with the school's character and direction. This school wanted software that was reliable, easy to use and install, able to run on older donated computers, and suited the learning activities that support the New Zealand curriculum. Warrington School (n.d.) reported that OSS supported environmental concerns by using older computers which would normally end up as toxic waste.

2.9 Open Source Software in Education

Toro et al. (2020) identified a gap in the literature regarding the adoption of open source software in education. Therefore, the adoption and use of OSS is not well understood. Toro noted an increase recently in the analysis of the use of OSS for improving the efficiency and competiveness of institutions that use OSS.

Talib et al.'s (2019) study of the use of OSS in educational institutions revealed that, although OSS is increasingly being integrated into education, currently there is not much focus on integrating it into the educational sector in a strategic and productive way. Talib et al. (2019) reported that people are not used to OSS and barriers to its use included poor documentation, lack of support and lack of training and expertise. Benefits of OSS use included free/low cost, personalisation, open philosophy, open code base and the accessibility of the software.

Gupta and Surbhi (2018) conducted a small-scale research project to identify the level of awareness among Indian teachers of OSS in education and to document usage and barriers. The benefits of OSS in education include customisation, availability/reliability, performance, security, low cost and the open philosophy. Barriers to use of OSS include lack of knowledge, lack of training, lack of availability of hardware and awareness of the software. Suggestions for increasing the use of OSS in education included funding for OSS support, inclusion in syllabuses and training and technical support for teachers.

When Sharp and Huett (2006) reviewed literature on the use of OSS in education, they found that the open source model "provides a means for teacher educators, and educational software developers in general to create software that is sustainable, continuously improving and sharable" (p. 6). Sharp and Huett (2006) also point out that, because the OSS code can be modified, there is potential for students to improve software and it can be used as a development tool. Sharp and Huett (2006) described two case studies from South Africa for which the rationale for use of open source included cost saving and the ability to use older computers. “The majority of the research tends to be informational or anecdotal. A significant amount of empirical studies and actual evaluation of the effectiveness of Open Source Software as opposed to proprietary software was not found” (Sharp & Huett, 2006, p. 9).

When Rooiji (2009) conducted a literature review on the adoption of open source software applications in U.S. Higher Education, five themes concerning adoption of OSS in education were identified:

1. Social and philosophical benefits
2. Software development benefits
3. Security and risk management benefits
4. Software adoption lifecycle benefits
5. Total cost of ownership benefits.

Rooiji (2009, p. 696) noted: “The literature provides little insight into how open source software enables sound pedagogy or enables institutions to achieve a balance of sound pedagogy and technical efficiency.” Chua (2011, p. 1) commented that, regarding “the current academic scholarship on open source and education, there’s not much”.

Moon and Baker’s (n.d.) preliminary literature review on the adoption and use of OSS identified 37 case studies or reports. Only one case study (Waters, 2007) was concerned with education and the benefits of the adoption of OSS in schools. A literature review by Moon and Baker (n.d) highlighted the lack of empirical data to substantiate claims made about OSS.

Racero et al. (2020) examined students’ behaviour when using open source software. The students were recent high-school graduates who were training in open source software. Racero et al. (2020, p. 2) reported that OSS increased the quality of education in the three ways of “service level, student productivity and student satisfaction”. Interestingly Racero et al. found that OSS and education share the goals of collectiveness and cooperation. Racero et al. acknowledged that there is a gap in knowledge about the impact of OSS on education. Gonzalez-Barahona and Robles (2006) reported that the importance of localization of content, lack of customised tools for teaching and learning, and funding problems are motivating educators in Europe to embrace OSS.

2.10 Communities of Practice

The concept of communities of practice is relevant to this literature review in two ways. Firstly, OSS is created by a community of practice in the design, testing and use of the software. Von Hippel (2001) stated that "Open Source Software projects, among others, have led to innovation, development and consumption communities run completely by and for users" (p. 82). Secondly, this research was associated with the development of a community of practice of learning in schools. Moyle (2002) stated "the use of Open Source Software such as Linux is canvassed as a way of linking learners in communities of practice, and fostering learning organisations" (p. 1).

Wenger (2006) defined communities of practice as "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (p. 1) and listed three essential characteristics :

1. *The domain: The community of practice has an identity defined by a shared domain or interest. Members of the domain value their collective competence and learn from each other.*
2. *The community: In the pursuit of a common goal, members of a community work and interact together. Information is shared and members assist each other. Members identify themselves as members of a specific community: joined by their shared practice.*
3. *The practice: The shared practice links the practitioners together. "They develop a shared repertoire of resources, experiences, stories, tools, ways of addressing recurring problems – in short, a shared practice" (p .2).*

Wenger (2006) identified the challenge for schools as being how to organise learning that is grounded in practice through a shared learning experience. Eckert (2006, p. 1) describes "the notion of a community of practice as the basis of a social theory of learning".

Rogoff, Bartlett and Goodman-Turkanis (2001) stated that the implication for schools utilising the community of practice concept is that they must prioritise instruction that builds on children's interests in a collaborative way. "Such schools also need to be places where learning activities are planned by children as well as adults and where parents and teachers not only foster children's learning but also learn from their involvement with children" (Smith, 2009, p. 7).

Table 2.3 *A snapshot comparison of groups after Wenger & Snyder (2000, p. 142)*

Type of group	What is the purpose?	Who belongs?	What holds it together?	How long does it last?
Community of practice	To develop members capabilities; to build and exchange knowledge	Members who select themselves	Passion, commitment, and identification with the group's expertise	As long as there is interest in maintaining the group
Formal work group	To deliver a product or service	Everyone who reports to the group's manager	Job requirements and common goals	Until the next reorganisation
Project team	To accomplish a specific task	Employees assigned by senior management	The project's milestones and goals	Until the project has been completed
Informal network	To collect and pass on business information	Friends and business acquaintances	Mutual needs	As long as people have a reason to connect.

Table 2.3 illustrates some differences between a community of practice group and more-formal groups (work group, project team, informal group) that are organised in a more-structured way (Wenger & Snyder, 2006).

Moyle (2002) cites a case study in Australian school where students were introduced to the Linux operating system and used OSS in project-based learning and solved authentic problems together. "Students were successful in their studies and left school with skills that would be useful to them throughout their lives" (p. 15).

Murray (2012), in an article on learning as a community, explained how Chris Clay, an Auckland High School science teacher, introduced students to participating in online communities involving sharing information, discussing issues and participating 24/7. Chris Clay aimed to enable the students to learn collaboratively and not in isolation. “As communities of practice generate knowledge, they renew themselves. They give you both the golden eggs and the goose that lays them” (Wenger & Snyder, 2000, p. 143).

When Daly, Pachler and Pelletier (2009) conducted an extensive literature review on continuing professional development in ICT for teachers, they found little research in this area and an inconsistency in the quality of Information Communication Technology Continuing Professional Development (ICT CPD) between schools. Daley et al. (2009) stated that pedagogical change is necessary for integration of ICT to be effective and that “many of the features of successful ICT CPD indicate that a community of practice has been established within the school or as part of a wider programme” (Daly et al. 2009, p. 7). Recommendations included the need for personalisation of delivery of ICT skills and pedagogy to individual teachers and that schools need to take pro-active steps to develop a learning community of practice within the school (Daly et al., 2009).

Communities of Practice have moved online. When Linton (2017) explored how an electronic learning communities (eLC) was established in a state virtual high school, case-study participants reported that the eLC “impacted their practice and connected them to colleagues with whom they could collaborate and problem solve” (p. 238). Linton (2017, p. 253) concluded that the eLC process was “authentic, genuine, accessible and student centered”.

2.11 ICT and Learning Theory

Mayers (2020) discusses constructivism and the role of technology in helping learners to become independent thinkers. Key concepts are associative learning, cognition and situative learning for which technology has a role in connecting to significant others. Mayers reinforces the role of social constructivism in which students learn through their interactions with others in the context of the wider culture. Mayers (2020) concludes that a new understanding of learning is emerging and is influenced by learning on networks (connectivism) and counterbalanced by existing learning theory (constructivism).

Roblyer, Edwards and Havrulik (1997, p. 55) commented that “subsequent years have witnessed two trends with unprecedented effects on the course of educational technology: (a) an increase in the number and types of technology resources available and (b) dramatic shifts in beliefs about the fundamental goals and strategies of education itself".

Behaviourism was originally linked to computers and learning through the development of teaching machines and software specifically designed to teach skills (Brown, 1995). Lever-Duffy, McDonald, and Mizell (2005, p. 14) stated that behaviourists "view all behaviour as a response to external stimuli. A stimulus is an initial action directed to the organism, and a response is the organism's reaction to that action." Brown (1995) explained that learning is externalised and that mental processes are visible with behaviourism. Lever-Duffy et. Al. (2005) identified B.F. Skinner, Ivan Pavlov and John Pavlov as key theorists behind behaviourism. The computer provides the stimulus and which prompts a learner's response which is reinforced by the computer (Roblyer, Edwards and Havrulik, 1997); this type of learning is commonly known as drill and practice. The classic mathematics games which teach mathematical concepts are a good example of the behaviourist pedagogy used with the computer in the classroom (Protopsaltis, n.d.).

Because of concerns that behaviourism takes no account of internal thoughts when processing information, the cognitivist perspective was formed (Roblyer et al. 1997). Lever-Duffy et al. (2005, p. 15) explained: "Cognitive theorists attempt to explain that learning in terms of how one thinks. Learning and problem solving, according to cognitivism, represent mental processes that are undetectable by mere observation." Roblyer (2004) asserts that Gagne was a cognitivist theorist who included both behaviourist theory and the information-processing theory in his toolkit for teachers, with learners progressing in hierarchical steps in their learning. Teachers could use technology to deliver increasingly-complex information to students (O'Riley, 2014).

Constructivism is a cognitive theory in which the locus of control is with the learner when computer technology is used as a mind tool complementing mental processes (Semple, 2000). Lever-Duffy et al. (2005, p. 15) describe constructivism as "an entirely unique product for each individual based on the experiences within which those mental processes occurred". Roblyer (2004, p. 65) associates theorists such as John Dewey, Lev Vygotsky, Jean Piaget, and Jerome Bruner with some of the fundamental premises of constructivist thinking. As a result of an individual's experiences with the environment, individuals construct their own concepts in their brain as a result of the interaction (Hein, 1991). The implication for integrating ICT is that learners should interact with sensory data and construct their own world view (Hein, 1991).

Discovery learning is associated with Bruner. As cited by Roblyer and Doering (2010, p. 41), Bruner stated that "active participation, he felt, was best achieved by providing discovery learning environments that would let children explore alternatives and recognise relationships between ideas".

Vygotsky linked learning as socially grounded within a culture (Brown, 1995). Social-cultural theory, part of constructivist theory, emphasises the role of culture and language in learning. Social-cultural theory is also called social constructivist theory, with children's interactions with people being important in their cognitive development (Adam, n.d.). Brown (1995, p. 2) lists three basic tenets of the social cultural theory: "(a) the importance of culture; (b) the central role of language; (c) the zone of proximal development (ZPD)." "The computer can provide a supportive context for learning by acting as a partner in dialogue and as a more capable peer that amplifies cognitive processes" (McInerney & McInerney, 2010 as cited in Brown, 1995, p. 2). Brown (1995) also comments that the computer is a cultural medium for student–student and student–teacher interaction and that the catalyst for social learning is the Internet. Brown and Adler (2008, p. 18) stated that "The most powerful impact of the Internet is its ability to support and expand the various aspects of social learning".

Siemens (2006, p. 1) stated: "The result is a fundamental mismatch between how we pursue and provide education and the context and characteristics of knowledge. We are preparing learners for an era that no longer exists, with a skill set that does not enable effective navigation of today's complex adaptive world." Siemens argues that the traditional learning theories of behaviourism, cognitivism and constructivism are no longer relevant in a society where knowledge is created and shared via networks. Connectivism is an emerging theory and seeks to explain how people learn via networking through living in our increasingly-connected society. Knowledge now rests within networks, not individuals, and the learning process is ongoing (Siemens, 2006). Giesbrecht (2011, para. 1) characterised connectivism as being "about forming connections between people and with technology". Connectivism relies on informal participation in communities of practice through online networks (Giesbrecht, 2011).

2.11.1 Open Pedagogy

Hegarty (2015) defines open pedagogy as a broad range of attributes from participatory technologies to innovation and creativity. Weller (2013, p. 10) states that open pedagogy "makes use of abundant, open content (such as open resources, videos, podcasts), but also places an emphasis on the network and the learner's connections within it". Open educational practices have been defined by Cronin (2017, p. 16) as "a broad descriptor of practices that include the creation, use, and reuse of open educational resources as well as open pedagogies and open sharing of teaching practices. Open pedagogies have been a strong influence on the pedagogy practised at the case-study school in this research.

Wiley and Hilton (2018, p. 133) propose the new term 'OER-enabled pedagogy' which is defined as "the set of teaching and learning practices that are only possible or practical in the context of the 5R permissions that are characteristic of OER". The 5R activities which are similar to OSS principles are retain, reuse, revise, remix and redistribute. Wiley and Hilton (2018, p. 144) argue that assessments should be authentic and related to the learning outcomes and not disposable (in the case of essays, etc.) and that OER-enabled pedagogy leads "to changes in student creativity, enthusiasm, satisfaction and other outcomes sometimes labelled as deep learning".

2.12 Commonly-used Open Source Software the Case-study School: Moodle, Mahara and Wikis

Moodle, an OSS learning management system developed by Martin Dougiamas, has become the world's leading learning management system (Dunn 2012). "Martin Dougiamas is an educationalist who has smartly combined the pedagogical knowledge of education and computer technology together which enriches the education of the 21st Century" (Nordin, Ibrahim, Hamzah, Embi, & Din, 2012, p. 216). Costello (2013) comments that a large open source community is continually developing Moodle and, as a result, it has become a very powerful, up-to-date and user-friendly learning management system. Chung and Ackerman (2015, p. 217) reported that "students most valued the control that Moodle gave them over their educational progress and that communication was an important benefit students sought in Moodle".

Bradac et al. (2017) investigated the possibility of offering a more-personalised online learning experience using the Moodle LMS software. The authors recommend that the online facilitator be used to survey students and respond to user feedback in modifying the online course to suit students' needs, thus resulting in a more-efficient and student-friendly learning environments. Of the students surveyed regarding the ability to personalise the content of Moodle, 29 out of the 30 students agreed. Personalisation of the Moodle experience could be a further development of the LMS.

Eportfolio software, which is used when learners reflect on learning, record evidence of learning and showcase learning achievements, is becoming increasingly used by schools to replace paper-based portfolios of learning (Gerbic, Grey, Moore & Bernay, 2009). Mahara is an example of open source ePortfolio software (Catalyst, n.d.). Giannandrea (2012) stated that Mahara ePortfolio has enabled students to have a better awareness of their learning process and gain understandings through critical reflection and peer feedback. Buzzetto-More (2010) rated Mahara ePortfolio software highly as a standalone open source portfolio with the ability to integrate seamlessly with the Moodle LMS.

Lewis (2015) researched Mahara ePortfolio use in initial teacher education as a learning tool and recommended a shift in focus away from a tool to the pedagogical capability of supporting learning reflections and developing metacognitive skills. Lewis (2015) concluded that ePortfolio software is best used for critical reflective practice in which students receive feedback from the tutor. EPortfolios are not stand-alone tools but need to be integrated into pedagogy.

Luce-Kapler (2007, p. 215) described wikis as "as easily learned, Open Source Software programs that allows all users to access and edit the pages on an ongoing basis". Wikipedia is the best-known wiki for which thousands of subject experts have created an accurate web-based encyclopaedia which has proved to be as accurate as Encyclopaedia Britannica (Terdiman, 2005). "Wiki is the Hawaiin word for quick and beautifully describes how users can, within minutes, create web pages" (Luce-Kapler, 2007, p. 215). Godwin-Jones (2003) state that wikis could be useful for building communities of practice by students creating a collective repository of learning experiences over time. Johinke and Lauro (2020) add that Wikipedia can be a valuable tool in the classroom by enabling students to challenge critically information in Wikipedia and to understand the mechanisms of collaborative research and writing.

2.13 Open Source Software in Narrowing the Digital Divide

Stats NZ (2004, para. 9), New Zealand's official data agency which collects information from people and organisations through surveys, defines the digital divide as "the gap that exists between different types of households and geographic areas with regard to their opportunities to access information through the internet". Ragnedda (2019, p. 27) argues "in a digital enabled society, part of the human activities depends on how we access, generate and process information". Both OSS and Open Educational Resources (OER) have the potential to reduce the gap in the digital divide. Lane, (2009, p.1) argues that, because the digital divide might be widening, deliberate "actions may be required by many intermediaries to help reduce the diverse social and cultural digital divides within education, including through the mediated use of open educational resources between teachers and learners." Wei and Hindman (2011) claim that socioeconomic status is closely associated with skills in the use of online information that is accessed via the internet. Bendici (2017) reported an initiative for bridging the digital divide in low-income areas in America to ensure that all students have equal access to educational technology from school or home. Local districts have developed their own digital textbooks and provide community Wi-Fi access. Bendici (2017) reports that schools lease low-cost chromebooks with access to school-supplied software with a spinoff or a 25% reduction in electricity costs through chromebook use.

Whitehurst (2009) argues that OSS can narrow the divide between education, business and the community, and that young people today use web 2.0 technologies to customise their own web presence through web applications, such as Facebook, Wikipedia, YouTube and Twitter, to control the look and feel of their social networking sites. Whitehurst also argues that OSS drives innovation and collaboration between students and enables connectivity and collaboration to solve real-world problems.

2.14 Impact of Covid on Education and OSS

The Covid-19 pandemic had a dramatic effect from 2020 on the delivery of learning in schools at all levels and affected the mental health of both teachers and students during lockdown periods (Hoofman & Secord, 2021). Brown et al. (2021) found considerable differences in learning as schools and universities changed from face-to-face learning to emergency remote online learning during and after the lockdown periods. Brown et al. (2021) stated the pandemic is an opportunity to change systems and practices for learning. The transition to online learning is an opportunity to develop interactive and co-operative learning environments. Doucet et al. (2020) and Khan (2021) noted that professional development was needed to assist teachers who did not use information communication technologies in their classroom and struggled to deliver learning online. As schools transition from remote online learning to school-based learning, a new teaching approach labelled Hybrid learning has developed with schools providing both onsite teaching and remote learning at the same time (Ministry of Education, 2022).

Despite OSS being freely available to teachers and students, a search of the library databases at Wintec where I am employed located no specific research results concerned with the impact of the pandemic lockdowns on OSS use in education. Bhat (2020) reported that, during the first months of lockdowns, teachers scrambled to locate digital tools to create a virtual classroom for engaging their students in learning. Bhat (2020) listed a number of digital tools used by teachers, including Zoom videoconferencing (proprietary SaaS video software), Google Classroom (SaaS cloud software) and other cloud-based SaaS softwares. No OSS featured on Bhat’s (2020) list.

2.15 Conclusion

This literature review has identified the need for change and innovation within education in order to educate and prepare learners to live and work effectively in the future. The conservative nature of education has been identified and ways in which education change can be achieved have been discussed. The future of education has also been speculated upon and the rapid change in technology has been identified as reinforcing the need for education to change. The key for schools is to be more flexible/open and to change pedagogy to take full advantage of emerging technologies in meeting the needs of the learners.

Some historical background about information communication technologies has been considered together with a need to reflect upon lessons learnt in the past. History shows us that ICTs have not been well utilised by most schools. Successful use of technologies relies on appropriate pedagogy and integrating of ICTs into the classroom environment.

The background of OSS was discussed, including consideration of free and open concepts. Despite the open and successful attributes of OSS and its success in the internet environment, OSS has yet to make a significant impact in the PC desktop environment. When Open Source and proprietary software were compared, each was shown to have advantages.

More specific to my research topic, case studies of the implementation of OSS in schools were reviewed. A literature search revealed a shortage of high-quality and focussed research for the combination of 'OSS' and 'effective implementation in schools'. Many case studies tended to be descriptive with little analysis about either the impact on the school stakeholders or the pedagogy used in the school.

Moyle and Ruwordt (2004) reported that the introduction of OSS into a school received positive comments from all major stakeholders. Teachers agreed with the open philosophy of the OSS, but they wanted professional development (PD) in the use of the software to speed up the learning curve. Students were very positive, liked to be able to use the same software at home and at school, and valued the virus security that OSS offers. There was no mention of a change in teaching pedagogy in the research.

Thornburg's (2007) research revealed that the introduction of OSS increased the use of ICTs as tools that facilitated learning. Many students did not realise that they were using OSS on the school computers. However, a link between access to computers and increased student learning is yet to be established.

Klein's (2008) research on providing schools with Indiana Linux is significant in the context of this research. In the inAccess programme, 22,000 workstations were provided in 24 high schools in Indiana using Linux and open source applications such as Open Office. Students became more engaged and positive about learning. The cost of providing hardware and software was considerably lower than for proprietary software. Although there is a lack of hard evidence regarding learning improvements, students commented positively about OSS. No mention was made of changes in teacher pedagogy or professional development.

The Lin and Zini (2005) study involved high-school students contributing to an open source thesaurus for OSS office software. Students became involved in a community of practice within an OSS community for whom the learning was engaging and authentic. Students had no problems adapting to the use of the software and the OSS was used to raise digital literacy within the high school.

Two descriptive case studies in New Zealand were located on the WikiEducator website, which described the benefits for two schools which used OSS for teaching and administration. The case studies were primarily descriptive and showcased the use of OSS within the schools. The use of OSS fitted into both schools' open philosophy.

The community of practice concept is very important in research into the use of OSS in schools in terms of both the community of practice within the OSS community and the community of practice that evolves within the school around the use of the software. Because of the rise in the use of social networking use amongst students, the community of practice concept has become important in schools.

Connectivism is an emerging theory that is embedded into the community of practice concept and which, in combination with social constructivism, influences the pedagogy of students in schools.

One of the most influential examples of OSS in education is the Moodle learning management system (LMS) for which a large open source community is using and continually developing the software for educational use. Mahara, an OSS ePortfolio software, is used in schools to enable students to reflect on learning through critical reflection and feedback. Wikis are shared websites that enable students to build a collective online resource using a community of practice.

Covid lockdowns in 2020–2021 had a large impact on the delivery of education by forcing teachers to deliver lessons online (Ministry of Education, 2022). A search of academic journal databased revealed that OSS had little impact because the majority of Hybrid learning involved Cloud-based SaaS software.

This case study on an open source high school was built on previous OSS educational research, but this literature reviewed identified a lack of recent research on the impact of OSS in schools. In particular, this literature review has identified a gap in the existing research specifically related to any new or existing high schools utilising an open teaching environment coupled with the sole use of OSS. Therefore, my research has the potential to make a contribution to filling the gap because I researched an open senior high school which uses OSS exclusively for both teaching and administrative.

Chapter 3 introduces and examines the research methodology utilised in this research.

Chapter 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This research identified factors for the effective implementation of open source software (OSS) in a senior high school to engage, create, communicate and contribute to high-order learning.

Chapter 3 discusses the research methods used in this qualitative case study of factors in implementation of OSS to support learning and teaching in a senior high school. Denzin and Lincoln (2008) state that qualitative research stresses "the socially constructed nature of reality, the intimate relationship between the researcher and what is studied and the situational constraints that shape inquiry" (p. 8). During the data-gathering phase, the researcher embedded himself within the school to establish trust with the Deputy Principal and to gain understanding of the pedagogy and information technology being used.

The school was treated as a case study, which Yin (2009, p. 18) defines in the following way:

> *A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real life context, especially when the boundaries between the phenomenon and context are not clearly defined.*

Farquhar (2002) explains that case-study research enables the researcher to gain an in-depth understanding into a particular phenomenon and within the context of the case. Harling (2002, p. 1) further defines a case study as "a holistic inquiry that investigates a contemporary phenomenon within its natural setting". In terms of this research, the phenomenon investigated was the implementation of OSS in education, with the natural setting being the high school. The combination of the phenomenon and setting comprised the bound system. The holistic inquiry involved the collection of data from direct observation, participant interviews, student surveys and documents (Harling, 2002). Case study is a method for understanding a problem in order to improve practice (Merriam, Mott & Lee, 1996).

Thematic Analysis also influenced my research design and data analysis. Clarke and Braun (2017, p. 297) define Thematic Analysis as “a method for identifying, analysing, and interpreting patters of meaning (themes) within qualitative data”. During the data gathering stage and beyond, thematic analysis influenced the identification of patterns and the coding stage “to capture both manifest (explicit) and latent (underlying) meaning” (Clarke & Braun, 2017, p. 298). Thematic Analysis was chosen as “a flexible analytical method that enables the researcher to construct themes or meaning-based patterns to report their interpretation of a qualitative data set” (Terry & Hayfield, 2021, p. 3).

My literature review identified the need for change in education to prepare learners for an ever-changing digital world; education often is slow to change. The literature review also identified a shortage of high-quality research on the implementation of OSS in schools in developed countries. Many case studies tended to be descriptive with little analysis of the impact on the stakeholders and the pedagogy used by the classroom teachers. A shortage of research into the use of OSS specifically in a senior high school was identified. Because the literature review established a need for research into how OSS is implemented in schools, my study potentially could make a meaningful contribution to research both in New Zealand and internationally.

This chapter provides a description of the methodology used to identify factors regarding the successful implementation of OSS for supporting learning in a school. This research used a combination of case-study and thematic analysis to identify the factors regarding the use of open source software in a senior high school. Chapter 3 discusses the research questions (Section 3.2), data sources (Section 3.3), population and recruitment (Section 3.4), methodology (Section 3.5), data-gathering methods (Section 3.6), data analysis (Section 3.7), research paradigm (Section 3.8) and research ethics (Section 3.9) before concluding with consideration of the research design and a conclusion (Section 3.10).

3.2 Research Question, Subsidiary Questions and Associated Research Methods

A model of a 21st Century school using OSS was developed in an attempt to understand the relationship between the software, pedagogy and factors in the implementation of OSS for learning and teaching in a senior high school. The role of technology was clearly defined along with other factors for the effective implementation of open source software in 21st Century learning.

The main research question involved *factors that facilitate or impede the effective implementation of OSS to support learning and teaching in a senior high school*. This involved researching the school as a single institution case study together with embedded case studies comprising the main stakeholders. The focus was the use of OSS to engage, create, communicate and contribute to high-order learning within the school. Factors that contribute to fostering a learning community that meets the needs of digital learners were identified. Based on the main research question above, the *four subsidiary questions* below were delineated.

1. *What do stakeholders perceive open source software to be?*

This question involved defining open source software and its relationship to education. The literature review in Chapter 2 considered the widely-accepted definition of OSS by Allcock, Chen, Killen and Simpson (p. 1, n.d.) as "computer software distributed under licence that allows end users to run and modify the software and re-distribute the software". This definition was compared with the stakeholders' definition and understanding of open source software.

2. *What do stakeholders perceive are the rationales behind the use of open source software?*

From all the major stakeholders' perspectives, the reasons behind the use of open source software in the school were investigated. Triangulation was important in comparing the different stakeholders' views. Kumar (2014, p. 386) defines triangulation as "the use of the same set of data from multiple sources to best achieve the objectives of your study". Through triangulation, the researcher gained a better understanding of the different stakeholders' rationales for using OSS by considering a variety of sources of data. More specifically, data triangulation enables the researcher to use different sources of information to gain an understanding of a concept (Denscombe, 2010).

3. *What do stakeholders perceive are the advantages and disadvantages of open source software in the educational context?*

Different stakeholder's perspectives were gathered concerning advantages and disadvantages for the school in using OSS. This was closely linked to the rationales for using open source software. Triangulation was used in comparing different stakeholders' opinions about advantages and disadvantages of OSS. Kasunic (2005, p. 15) describes "the purpose of triangulation as being to obtain confirmation of findings through convergence of different perspectives".

4. *What do stakeholder perceive is the pedagogy used in the classrooms by the teachers in relation to open source software?*

In the implementation of a 21st Century learning environment, the pedagogy used by teachers is a vital factor. Therefore, teachers were asked to explain the pedagogy used in their classrooms and how OSS was integrated into learning activities.

Qualitative data were analysed using coding which involves "the process of defining what data are about" (Charmaz, 2014, p. 111). "Coding means that we attach labels to segments of data that depict what each segment is about" (Charmaz, 2014, p. 4). Themes emerge from the data through coding to give the researcher evidence about how and why OSS is used within the school.

Qualitative and quantitative data were generated through online surveys responded to by students at the school. Kumar (2014, p. 150) notes that "the last few years have witnessed a substantial increase in the use of online surveys for researching social issues". The quantitative data were used to construct charts showing the frequency of different themes identified by students using spreadsheet software. The qualitative data were used to construct charts showing the frequency of technology use. A thematic analysis of the themes and codes was used to identify the pedagogy used by teachers and students in the school.

3.3 Data Sources

The stakeholders' chosen for this case study were the Year 11–13 students, teachers, senior management and Board of Trustees at the senior high school which is located in a high-income area of a large city. The data-gathering process was as unobtrusive as possible, with data-gathering at convenient times within the school timetable. I liaised solely with the Deputy Principal to negate any confusion amongst the staff and students.

3.3.1 Stakeholders

Representatives of all the major stakeholder groups were interviewed or surveyed in the data-collection phase of the research. Kumar (2014, p. 283) defines stakeholders in the context of research as "those with a direct and indirect involvement in a research study". Initially, the school was visited to discuss with the Deputy Principal whether the research was viable and whether the school agreed to be the subject of the case study. A walk-through of the school was conducted with the Deputy Principal to get an impression of the school, students and physical environment. Visits were also made to the school to gain an impression of its layout, routines and teaching environment. Appointments were made via the Deputy Principal for scheduling one-to-one interviews and focus-group interviews with stakeholders.

School students

The students were in the final three year levels of secondary school (Year 11, Year 12 and Year 13.) and resided in a large urban area with a small proportion of students of lower economic status. This school is classified as Decile 10 according to the following definition:

> *A school's decile rating indicates the extent to which it draws its students from low socio-economic communities. Decile 1 schools are the 10% of schools with the highest proportion of students from low socio-economic communities, whereas decile 10 schools are the 10% of schools with the lowest proportion of these students.* (Ministry of Education, 2013, para.4)

The school decile ratings are calculated from the NZ census of population and dwellings and take into account household income, occupation, household crowding, educational qualifications and income support (Ministry of Education, 2018a). It can be assumed that the students at the senior high school come from a largely-affluent urban area, which is significant for this study because it increased potential access to ICTs in terms of home computers and portable devices for students. In turn, this has implications for other schools seeking to replicate this senior high school's approach to using OSS.

Teachers

At the time of my study, the school had 50 teachers across all the major curriculum areas who were registered and met the Registered Teacher Criteria of the New

Zealand Teachers Council. There were 12 teachers who were responsible for the management of a curriculum area.

School management

The school had a principal and three deputy principals at the time of my study. The role of the management is to manage the teaching and learning environment within the school. The school principal is responsible for the overall management of teaching and learning, including liaising with the local community and parents. The deputy principals are responsible for assisting the principal with professional leadership throughout the school and are specifically responsible for teacher and student welfare.

Governors

The school is governed by an elected Board of Trustees comprised of five elected parent representatives, the principal, a staff member and a student representative. The Board's role is to govern the school and ensure that it is run in the best interests of students and the community.

3.3.2 Documents

The Education Review Office (2014) reported on the case study school in August 2014 and this report was referred to when writing the thesis. Research documents were found by searching the internet using the Google search engine. Many articles were also found using the Google Scholar email alert with 'open source' and 'education' as the key words. The library database at the Waikato Institute of Technology (Wintec) was also searched, with 'open source' and 'education' as the key words, and using Ebsco Host, Proquest and Google Scholar. A Wintec librarian provided expert guidance when using the library databases. The *New Zealand Herald* website (http://www.nzherald.co.nz) and the *Fairfax NZ* website (http://stuff.co.nz) were searched for past news articles using 'open source' and 'education' as key words. The *Interface* ICT education magazine website (https://interfaceonline.co.nz) was also searched for articles on OSS.

3.4 Population and Recruitment

The population for my research consisted of the stakeholders from the senior high school for the case study. Creswell (2014a, p. 140) comments: "In some educational situations, you will select individuals for your research based on who volunteers to participate or who is available (e.g. a specific classroom of students)." The researcher was reliant on the Deputy Principal to contact teachers who were willing to volunteer for an interview and to select students to volunteer for focus groups and the web survey.

3.4.1 Sampling

Bouma and Ling (2004, p. 112) state that "part of the whole is studied and the results are taken to be an accurate reflection of the whole". The researcher determined that the participants were representative of the total population by interviewing or surveying the relevant stakeholders in the school. As a researcher from outside the case study school, I was reliant on the contact Deputy Principal for selecting teachers and students for the interviews and focus groups.

All members of the school management were interviewed using protocol guidelines that were given to the contact Deputy Principal for the different stakeholder groups. The sampling method used for the qualitative study for the teachers, students and Board of Trustees involved self-selection with participants volunteering to be part of the research (Mukherji & Albon, 2018). Sections 3.4.1.1 to 3.4.1.5 describe the selection of the stakeholders for the focus groups, interviews with teachers, school management and governors, and the web survey.

3.4.1.1 Focus groups

A focus group, as defined by (Kumar, 2014, p. 193), is a "group interview where you explore the perceptions, experiences and understandings of a group of people who have some experience in common with regard to a situation or event". The Year 11, 12 and 13 students for the three focus groups were selected by the Deputy Principal from the tutorial classes. Ten students from each year level were invited to take part in focus groups that had a balance of genders and comprised students selected from the Deputy Principal's tutor groups which met every Tuesday and Thursday morning from 8.30am – 10.30am. The aim of the tutor group meeting was for students to discuss school issues with their mentor teachers in small groups. During this time, the focus-group session took place and was recorded digitally and transcribed. The students and caregivers signed an information and consent document.

3.4.1.2 Teachers

The case study's aim was discussed with the teachers at a staff meeting via the Deputy Principal and the staff were asked to volunteer for a one-to-one interview on the topic of OSS and learning. Ten teachers, five male and five female, were interviewed for 30 minutes each. A date was set when the teachers could be interviewed in one day following a schedule organised by the Deputy Principal.

3.4.1.3 School management

The Principal and three Deputy Principals were interviewed to obtain the management's perspective on OSS within the school. The date and times for the interview were organised by the Deputy Principal.

3.4.1.4 Governors

Members of the Board of Trustees were invited via email by the Deputy Principal to respond to a brief questionnaire about their understanding of OSS in by the school. Two Board of Trustees members responded to the email questionnaire.

3.4.1.5 Web survey

Denscombe (2014, p. 14) defines a web-based questionnaire as "a web page located on an internet site waiting for people who visit the site to complete it". The population for the web survey about OSS and its use in the school was the Deputy Principal's pastoral care tutorial group. The tutorial group meets weekly including students from year 11,12 and 13 when the Deputy Principal supports students by offering advice and support for student welfare and learning. When an email link which was distributed to students via the Deputy Principal, the online web-survey was completed by 92 students out of a total of 713 students (13%). Students who responded were from the Deputy Principals pastoral care tutorial group which comprised of Year 11, 12 and 13 students. Denscombe (2014) states that a web survey or internet survey has the advantages of being low-cost, data being easily analysed, providing instant results after completion, and the quality of data being the same as traditional survey methods.

3.4.2 *Recruitment*

Patel, Doku and Tennakoon (2003, p. 229) defined recruitment as dialogue which "begins with the identification, targeting and enlistment of participants for a research study". Participants for this research were organised through the Deputy Principal who had access to the stakeholders within the school. This involved recruiting a sample that represented the target population in sufficient numbers to meet the study's sample size target.

3.4.2.1 Focus groups

The Deputy Principal invited 10 students randomly from his tutor group to take part in the focus group. A balance of females and males was achieved. Each year group was interviewed separately after a permission document was given to each student for the caregiver and student to sign. Those students who returned signed permission slips were invited to join the focus groups which were held weekly during tutor group meetings.

3.4.2.2 Management and teacher interviews

Through emails from the Deputy Principal, 10 teachers and senior management staff were invited to participate in 30-minute interviews with the researcher. Information sheets and consent documents were given to the teachers to read and sign well before the interview. All senior management staff participated in an interview at a time and place arranged by the Deputy Principal.

3.4.2.3 Web survey

All students were invited by the Deputy Principal via an email link to participate in the web survey. The first question contained participant information/consent. The students clicked 'yes' to agree before continuing with the survey questionnaire. Students completed the web survey during a study period.

3.5 Methodology

Methodology describes the "overarching research method that links clearly to a theoretical framework" (Mutch, 2009, p. 221). Creswell (2003) discussed how research lies on a continuum between qualitative and quantitative methods; my research was more qualitative in nature. Creswell (2003, p. 179) acknowledges that: "Qualitative inquiry employs different knowledge claims, strategies of inquiry, and methods of data collection and analysis". Much of the data in this study relied on the opinions and views of the major stakeholders in the use of open source software within the school. Therefore, this thesis is firmly grounded in the qualitative domain of inquiry.

Creswell (2013, p. 46) has delineated characteristics of qualitative inquiry that match the research methods used in my study:

- *"Is conducted in a natural setting, a source of data for close interaction*
- *Relies on the researcher as key instrument in the data collection*
- *Involves using multiple methods*
- *Involves complex reasoning going between inductive and deductive*
- *Focuses on participants' perspectives, their meanings, their multiple subjective views*
- *Is situated within the context or setting of the participants/sites*
- *Involves an emergent and evolving design rather than tightly prefigured design*
- *Is reflective and interpretive (i.e., sensitive to researcher's biographies/social identities*
- *Presents a holistic, complex picture*

Adopting qualitative research procedures involving a case study/thematic analysis approach allowed me to gain insight into the use of OSS within the school community. However, some of the data generated in my study were quantitative, particularly those from the online survey, and these data were processed to form charts using a spreadsheet computer programme to supplement the main qualitative approach used in this thesis.

3.5.1 Instrumental case study

The purpose of any case study is to understand human interaction within a social unit (Stake, 1995). For my specific case study, the purpose was to research and discuss teacher and student interactions when using open source software for learning within the community of practice of a school. Creswell and Creswell (2018. p. 14) state:

"Cases are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time."

An instrumental case study is used to provide insight into an issue (Stake, 2000). The main issue in my study was using open source software within a school to support learning. The case-study school played a supporting role and investigating the school provided me with insight into the role that open source software plays within the learning context. According to Denscombe (2010, p. 52):

> *Case studies focus on one (or just a few) instances of a particular phenomenon with a view to providing an in-depth account of events, relationships, experiences or processes occurring in that particular instance.*

Merriam and Tisdell (2016, p. 37) summarise case studies as "searching for meaning and understanding, with the researcher as the primary instrument of data collection and analysis, and inductive investigative strategy, and the end product being highly descriptive". The case is the school (bounded system) using open source software and the goal is to investigate the stakeholders' views on the use of open source software in their learning. A succinct definition of a case study is "an in-depth description and analysis of a bounded system" (Merriam & Tisdell, 2016, p. 40).

Patton (2015, p. 259) states that "the case study stands on its own as a detailed and rich story about a person, organisation – whatever the focus of study". The senior high school studied was a unique learning organisation that is based on an open learning philosophy in architecture, organisation and the use of open source software for learning and administration. Yin (2012, p. 6) adds "the boundary between the case and its contextual condition – in both spatial and temporal dimension – may be blurred".

Although my case study was focussed solely on open source software initially, there was shift in focus during the research to thematic analysis in order to give me flexibility to follow leads. The leads that were identified are discussed in the Results and Discussion chapters in this thesis (namely, Chapters 4 and 5).

3.5.2 Thematic Analysis

The thematic analysis (TA) method was chosen because "thematic analysis provides a flexible and useful research tool, which can potentially provide a rich and detailed, yet complex account of data" (Braun & Clarke, 2006, p. 5). Braun and Clarke (2006) define thematic analysis as “a method for identifying, analysing, and reporting patterns (themes) within data. It minimally organises and describes your data set in (rich) detail.” Boyatzis (1998) states that thematic analysis often goes further than this and interprets various aspects of the research topic. A key feature of TA is that it is a method rather than a methodology. Nicholls (2009) defined a method as a tool that we use to do the tasks of research, slotted into the wider research design, depending upon the needs of the project. Terry and Hayfield (2021, p. 8) state that “Thematic Analysis is simply a tool for qualitative data analysis”.

There are different versions of TA, with this research aligning closely with reflexive TA (Braun et al., 2019). Terry and Hayfield (2021, p. 4) explain that “central to reflexive TA is the idea of reflexivity, or the importance of the researcher’s interpretation of the data”. Terry and Hayfield (2021, p. 4)) further explain that “analysis occurs because of rather than despite the researcher's subjectivity, values, backgrounds, decisions and interests”. The discussion of the results of the qualitative case study is influenced by my background as a primary teacher and my current role in leading a Graduate Diploma in Information Technology in Education.

Terry and Hayfield (2021, p. 4) outline the core values of reflexive TA.

a) *Theoretical flexibility*
b) *procedural focus on a systematic, ever-increasing and rigorous engagement with data*
c) *emphasis on the reflexive contribution of the researcher*
d) *framing of ‘themes’ as multifaceted, conceptual, meaning-based patterns.*

Reflecting on the core values of TA, the researcher has rigorously engaged with the data using my experience as a teacher who integrated ICTs into my pedagogy and has facilitated a wide range of digital tools in upskilling practising teachers over the last 20 years. TA has enabled flexibility in interpreting and displaying the results of the data collection, with themes having been generated from the interviews, focus groups and online surveys on the use of OSS in the case study school.

Braun and Clarke (2013, p. 202) describe the stages of coding and analysis using the thematic analysis method:

1. *Transcription*
2. *Reading and familiarisation; taking note of items of potential interest*
3. *Coding – complete across entire dataset*
4. *Searching for themes*
5. *Reviewing themes (producing a map of provisional themes and subthemes and relationships between them*
6. *Defining and naming themes*
7. *Writing – finalising analysis.*

Once the face-to-face interviews and focus group interviews had been completed, the seven-step process from Braun and Clarke (2013) was followed. The audio files from the interviews were transcribed by an independent contractor and the researcher printed and read the transcriptions thoroughly. Braun and Clarke (2013, p. 204) describe the familiarisation process as becoming "intimately familiar with your dataset's content, and to notice things that might be relevant to your research question". Initial notes were made in the margins of themes of potential interest.

The interview questions were centred around the research questions and, during the coding process, themes were identified and noted on the transcripts. A complete coding process was used (Braun & Clarke, 2013) with the aim being to identify everything of interest or relevance to answering the research question.

Terry and Hayfield (2021, p. 43) describe theme generation "as making sense of your list of carefully developed codes and clustering or combining codes to construct multifaceted and meaningful patterns that answer your research question". Themes were developed from clustering codes with codes grouped according to similarity (Terry & Hayfield, 2021). The second process of creating themes from the codes was promoting codes. Terry and Hayfield (2021. p. 48) explained the promoting codes process as "some codes might be prevalent and rich enough that they could have a central organising concept of their own and important enough to be promoted from code to candidate theme". Themes were then created from the data to answer the research questions.

When reviewing the themes, the researcher established a list of themes around a research question and colour coded the themes. The transcripts were then re-read and, using coloured markers, the text themes were identified on the script. The frequencies of theme occurrences were then counted and logged according to the stakeholders. Themes were modified according to the research question category. Graphs and diagrams were then constructed showing the relationships between the themes and research questions and then inserted into the results discussions. The resulting diagrams and graphs were then used to discuss the relationship of the themes to the research questions in the discussion section.

The final stage of thematic analysis was writing the results and discussion chapters to complete the thesis. In the results chapter, the themes are presented related to each research question. Terry and Hayfield (2021) recommend that the themes are reported in the results section and are linked the literature in the discussion section. Terry and Hayfield (2021, p. 71) state that, "during this phase, you may have some of your most insightful ideas, so be willing to let things go and to potentially make final meaningful changes to your themes".

Peterson (2017, p. 1)) summaries thematic analysis as "reviewing the data, making notes, categorising data into themes, searching for developing patterns, assessing the applicability of the findings to the questions posed in the study, and ultimately synthesising and writing the findings and interpretations" which summarises the research methods used in the thesis research.

3.6 Data-gathering Methods

In my research, a variety of methods was used to collect data for analysis and synthesis. The purpose of using a variety of data-gathering methods was to permit triangulation (Mukherji & Albon, 2018) and therefore enhance the validity of research findings.

3.6.1 Email survey of Board of Trustees

A brief open-ended email survey was forwarded to the Board of Trustees members by the Deputy Principal. Coderre and Mathieu (2004) state that, provided that open-ended questions are used, email surveys can give the same quality of data as either telephone or mail surveys. The opinions from the Board of Trustees members was also valuable in the triangulation of the data.

3.6.2 Interviews

Mukherji and Albon (2018, p. 238) define an interview as "a method where one person as questions of an individual with the expectation of getting answers to a particular question on a particular topic". Thirty-minute face-to-face interviews were undertaken with school management (Principal and Deputy Principals), teachers, the IT technician and office administrators. Consent forms and questions were given to the interviewees before the interview. The timetable and scheduling were organised by a Deputy Principal. The interviews were recorded by the researcher and transcribed by a contracted transcriber. The interviews were classified as semi-structured (Denscombe, 2010) in that, although there was a list of specified questions asked, some flexibility was allowed if the interviewee wanted to speak more widely on the issues covered.

The topics for the interviews covered the sub-questions of the thesis. The open-ended questions were "focussed on understanding your central phenomenon in the study", (Creswell, 2014b, p. 163). Charmaz (2014, p. 65) stated "most researchers use intensive interviewing to explore, not to interrogate". A quiet place was located for the interviews which was free from distractions and allowed a clear audio recording to be made (Creswell, 2009). All interviews followed the procedures recommended by (Robson, 2011):

- Start interview digital recorder
- Welcome interviewee
- Explain consent process and take signed consent form
- Begin with an easy question
- Ask subsequent interview questions from interview schedule.
- Allow for any deviation from structured questions
- Ask if interviewee has any other comments
- Conclude interview
- Stop digital recorder
- Transcribe interview
- Email interview document to school for interviewee to view.

3.6.3 Focus groups

According to Nagle and Williams (n.d.), "focus groups provide insights into how people think and provide a deeper understanding of the phenomena being studied" (p. 2). Focus groups were used for interviewing students in the school and to enable the researcher to provide a comfortable group environment for students to discuss open source software and learning. Nagle and Williams (n.d.) also state that the focus groups enable the researcher to capture more in-depth information than with individual interviews.

Denscombe (2010, p. 177) defines focus groups as "small groups of people who are brought together by a moderator (the researcher) to explore attitudes and perceptions, feelings and ideas about a specific topic". Nagle and Williams (n.d.) point out that "focus groups provide insights into how people think and provide a deeper understanding of the phenomena being studied" (p. 2). The focus-group methodology generates rich and high-quality data around the phenomena being researched (Williams & Katiz, 2001). Additionally, during a group conversation, "a comment may encourage a train of thought in another" (Williams & Katiz, 2001, p. 3).

Denscombe (2014, p. 177) noted three distinctive features of focus groups:

- *"A focus which provides stimulus for the discussion*
- *Emphasis placed on interaction within the group for eliciting information*
- *Moderator's role in facilitating the group interaction."*

Nagle and Williams' (n.d.) five-stage process below was used during the focus-group process:

1. Study Purpose (To identify factors that facilitate or impede the implementation of open source software for learning within the case study school)
2. Methodology
    a. Conceptualisation (Focus group with 10 students, selected by year group by Deputy Principal. Open-ended questions selected that focused on probing subsidiary questions of the main research question)
    b. Logistics (Focus group held at the school in students' familiar environment. Scheduled focus-group meeting time and room to suit students. Question script prepared. Digital recorder organised. Participant information sheet prepared and sent to school prior to a focus group for

distribution and signing. Students informed of start time and end time. Refreshments provided for the group of students)

3. Facilitation
   a. Preparation (Interviewer arriving before time, setting up chairs in a circle around a table, preparing recorder, snacks and checking question sheet)
   b. Pre-Session (Friendly greeting of students, making students feel comfortable, explaining the purpose of the focus group)
   c. Session (Interviewer asks questions from a script, questions are open and focus-group question strategies used: pauses to allow reflection, probe questions used to follow a concept, inclusiveness to allow everyone a say and encouraging one person to talk at a time. Confidentiality stressed with no statements being able to be linked to an individual)
4. Analysis (Scripts transcribed and analysed using thematic-analysis coding. Themes identified and described in Chapter 4 of the thesis)
5. Reporting (Themes analysed and discussed in Chapter 5 of the thesis and used for triangulation purposes with the views of other stakeholders)

The Deputy Principal chose 10 students from his tutorial group in each Year 11, 12, and 13 student group. Students assembled around a circular table in a quiet room near their regular tutorial room where they met every Wednesday morning with their tutor teachers to discuss study issues. The focus groups in separate year groups were interviewed during different weeks. The Year 11 group was interviewed in March when they first attended the school and again in September after six months to find out if their views on OSS had changed during that time. The year 12 and 13 groups were interviewed in September only because they were in their second and third year at the school when their views on OSS were well established and stable. Time constraints and intrusion reasons also influenced the focus-group interview schedule.

Students were welcomed into the room and drinks and snacks were made available throughout the one-hour session to make them feel comfortable. The students had signed a consent agreement for the focus-group interview, which was recorded and transcribed by an independent transcriber. A distinction was made in the transcription between female and male responses, but no names were recorded. Prepared questions covered the research questions. During the interviews, some deviation was made from the scheduled questions if students' responses suggested a new lead (Flick, 2018). Nagle and Williams (n.d., p. 7) note that "the questions are important but maintain flexibility. If an issue seems critical to the participants and it aligns with the study purpose, explore it more in depth."

3.6.4 Web survey

Denscombe (2014, p. 14) defines a web-based questionnaire as “a web page located on an Internet site waiting for people who visit the site to complete it”. A Wintec Web SurveyMonkey account owned by my employer’s institution was used to host the web questionnaire for the Senior High School students to complete.

Details of the web survey were distributed by the Deputy Principal via email and the school intranet to all school students. Details of the timeframe to for responding to the survey were also distributed to the students. A movie ticket draw was used as an incentive to encourage students to take part in the survey. This meant that students needed to enter their school identification numbers in order to identify the winners. The researcher had access to the submitted identification numbers only and not to the student names associated with the identification numbers. The identification numbers were emailed to the Deputy Principal who distributed the tickets to the students. Students’ submissions were anonymous, which is an advantage of online surveys (Knussen & McFadyen, 2010).

The online survey software SurveyMonkey was used to gather quantitative and qualitative data from school students. Consent for the survey was obtained after students had read a participant information sheet which was attached the survey. Knussen and McFadyen (2010, p. 1) state that the consent procedure “can be addressed by presenting items normally found on a paper-based consent form such as the items must be endorsed before the next page can be opened.”

The University of Exeter (2012) states that advantages of online surveys include administration speed, lower cost, flexibility, accuracy, anonymity and ease of access for respondents, whereas disadvantages involve verifying identity, control, sensitivity, data security, data protection and bias. Student identities were anonymous in my study.

Quantitative data were available in the researcher’s user account from Survey Monkey in a spreadsheet format (xls). The researcher selects export data and the xls option is chosen to allow results to be downloaded to a computer for further analysis. Excel spreadsheet software was used to display the data as charts for analysis.

Qualitative data were exported in pdf format and downloaded to the researcher's computer to be copied and pasted into Word format.

3.6.5 Observations

Observation had a minor role in this research and was confined to students working in groups on their projects. Denscombe (2014, p. 197) would classify the observation methodology as natural setting observation intended "to observe things as they normally happen, rather than as they happen under artificially created conditions". The researcher visited the school on an Impact Project Wednesday to observe a morning session when students were working individually and in groups on their personal impact projects. The researcher moved between the groups and asked students about their projects and the software that they were using. The results of the observations are displayed in Table 4.2. Observations were limited because of time constraints, their potential intrusiveness (Corbin & Strauss, 2008) and the distance from the researcher's place of residence. Classroom observations were not made for the same reasons and also because of the time spent on focus-group interviews with the students. Observational notes were also made (Loftland et al., 2006) to provide a description of the setting and some informal interviews were conducted. In further research into the implementation of OSS in schools, increased use of classroom observations is recommended.

3.7 Data Analysis

Case-study and thematic-analysis approaches guided my data analysis and discussion. Creswell (2014b, p. 245) has defined qualitative data analysis as "making sense out of text and image data". The research also used quantitative data from student surveys with the intent of generalising from a sample of students within the case-study school regarding computer and software use (Keppel, 1991). My data analysis followed the qualitative methodology steps of Creswell (2003, pp. 191-192):

1. *"Organise and prepare data for analysis. Recorded interviews and focus groups were transcribed. Web Survey data were downloaded onto computer and printed out.*

2. *Read through all the data. All interview, focus group and web survey responses were read. Notes were made in margins for any general observations and hunches.*
3. *Detailed analysis using a coding process. The information was organised into categories through reading through and making notes using coloured highlighters in the margins and on interview scripts:*
    a. *For each interview or focus group, write notes in margin.*
    b. *Write codes for common themes/ideas as they occur.*
    c. *Make list of topics from codes.*
    d. *Take list and write codes next to appropriate segments of text.*
    e. *Analyse codes and group into categories and draw diagrams of categories/codes.*
    f. *Assemble categories and perform preliminary analysis.*
4. *Use coding process to generate a description of the setting or people as well as categories or themes for analysis. Further refine themes.*
5. *Describe the themes that are relevant to the research.*
6. *Write about the themes related to the research questions in the results chapter.*
7. *Form visuals, figures or tables as representation of the themes.*
8. *Make an interpretation or meaning of the data in the discussion chapter. Reflect on the researcher's personal interpretation couched in the individual interpretation that the researcher brings from his background or experiences."*

Thematic analysis (Braun & Clarke, 2013) informed the coding process. Interview transcripts were coded into themes and then the significant/frequent codes were sorted, synthesised, integrated and organised (Braun & Clarke, 2013). Vaismoradi, Jones, Turunen and Snelgrove (2016, p. 101) define a theme as an "attribute, descriptor, element and concept". The coding process into themes followed two phases: firstly, each interview response was tagged as a code; and secondly, the most significant codes were sorted and analysed into themes (Braun & Clarke, 2013). Theories and conceptual models of the learning process involving open source software were generated by the coding process and synthesis of the data.

Quantitative data were collected from the online survey data about student use of ICT and open source software. Quantitative data were analysed using spreadsheet software and depicted as tables and graphs displaying student devices used and computer operating systems for inclusion in the results chapter. Bouma and Ling (2004, p. 149) stated that "data are summarised and presented so as to clearly demonstrate the strength of the relationship between the variables under study". Qualitative and quantitative data were analysed and displayed for inclusion in the Results chapter, namely, Chapter 4, and subsequently synthesised in the Discussion chapter, Chapter 5.

3.8 Research Paradigm

3.8.1 Ontology

My position as a researcher is that of a relativist in that I believe that "objects of thought are merely words and that there is no independently accessible thing constituting the meaning of a word" (Cohen, Manion & Morrison, 2007, p. 7). All phenomena are confined to our mind and must be observed. Haigh (2013, p. 20) explains:

> *In contrast, some people consider that reality is confined to what our minds conceive reality to be and that we can never have certainty that there is a world that exists independently of the one we construct in our mind. This is called the relativist ontological position.*

Creswell (2003, p. 18) states that:

> *… a qualitative approach is one in which the inquirer often makes knowledge claims based primarily on constructivist perspectives (i.e., the multiple meanings of individual experiences, meanings socially and historically constructed, with an intent of developing a theory or pattern) or advocacy/participatory perspectives. The researcher collects open-ended data with the primary intent of developing themes from the data.*

I acknowledge that my past experiences influenced my interpretation of the data. My background as a primary-school teacher, ICT facilitator, researcher and adult educator influences my world view and subsequent analysis of the data. As this case study developed, it was seen through my eyes as an experienced educator who integrates ICT into my teaching and it drew on my background to frame my perspective on pedagogy that integrates ICTs. Using a thematic-analysis perspective, the case study compared the attributes, meanings and understandings of the use of open source software in the senior high school.

3.8.2 Epistemology

In my research, I acknowledged my relativist position and drew upon my background in my Master's research and current teaching practice as an online ICT facilitator in making sense of the place of open source software in the senior high school. My teaching experience has also helped the framing of the main research question and the subsidiary research questions. I acknowledge that research is a subjective activity and that, in this thesis, I share past experiences that have shaped my thinking about the integration of ICT into learning.

My position is that of a constructivist. Crotty (1998, p. 43) asserts that “meanings are constructed by human beings as they engage with the world they are interpreting”. I have built upon my past experiences with ICT and education in interpreting the case study. Crotty (1998) also states: “Qualitative researchers seek to understand the context or setting of the participants through visiting this context and gathering information personally” (as cited in Creswell, 2003, p. 9). Throughout this case study, I aimed to establish a good relationship with the school through frequent visits both to explain the research and to gather data through focus groups and interviews.

Finally, Crotty states: “The process of qualitative research is largely inductive, with the inquirer generating meaning from the data collected in the field” (as cited in Creswell, 2003, p. 9). Thematic analysis (Braun & Clarke, 2006) was used for the coding process and to construct meaning from the data to enable flexibility and the construction of theories to explain the use of open source software for learning.

Flick (2009, p. 69) claims: “What is common to all constructionist approaches is that they examine the relationship to reality by dealing with constructive processes in approaching it.” “In the constructionist view, as the word suggests, meaning is not discovered but constructed” (Crotty, 1998, p. 42). Charmaz (2014, p. 17) states: “We construct our grounded theories through our past and present involvements and interactions with people, perspectives and research practices.”

3.8.3 Values

Because I adopted a relativist approach to this research, my personal values influenced my research. A key factor in my findings from my Master's research (Roberts, 2010) on digital classrooms was that the teacher was important in the success of integrating ICT into a classroom program. I acknowledge that I am interested in the teacher’s pedagogy as a main factor in the use of open source software in the classroom for teaching and learning. ICT is acknowledged as a digital tool (Fullan & Langworthy, 2013) which is used by both teachers and students to enhance learning opportunities.

3.9 Research Ethics

"The term ethics usually refers to the moral principles, guiding conduct, which are held by a group of or even a profession" (Wellington, 2000, p. 54). Because the research was concerned with people and their attitudes towards ICT in education, an application was made for ethics approval which was granted by the Human Research Ethics Committee at Curtin University. See Appendix D for a copy of the approved letter.

Bouma and Ling (2004, p. 188) state: "The key to identifying ethical issues in research is to take the position of a participant." The researcher has been a teacher and is aware of ethical issues from a teaching perspective. Prior to all interviews, focus groups and web surveys, participant information sheets and permission forms were provided to and signed by all stakeholders. Examples of the participant information sheet are in Appendix C of this thesis. "Informed consent is probably the most common method in social research" (Bailey, 1978, p. 384) and it involves subjects being made aware of the information discussed, why the information is being sought, the participation requirements and to what purpose the information will be put. Also, how a study directly affects the subjects is needed for informed consent (Kumar, 2014).

A participant information form was given to each potential research participant with an invitation to participate after the reasons for the research had been explained. Discomforts and risks were explained, as well as how the discomforts and risks would be minimised or alleviated through the research process. The benefits of the research were outlined from the perspective of both the individual and the school. The anonymity of responses to the interview questions was guaranteed, and the procedure for safeguarding the collected data were outlined. The participation information sheet ensured that Cohen, Manion and Morrisons' (2011) four conditions of informed consent – competence, voluntarism, full information and comprehension – were met. The interview transcripts were emailed back to the participants for comment and amendment to ensure that participants were in agreement with the opinions given. The signed participant information sheets were returned to the school and given to the researcher before the interview proceeded. Confidentiality was ensured by teachers and students being identified by number in the transcripts. Kumar states that “it is unethical to identify an individual respondent and the information provided by him/her” (2014, p. 286).

3.10 Research Design and Chapter Summary

This goal of this chapter was to outline the research design and methodology used to answer the main research question and the subsidiary research questions, whose rationale was discussed. The research questions were discussed in conjunction with the research methods used. The researcher’s ontological position as a relativist and epistemological position as a constructivist was explained. The contribution that this study could make to the research literature concerning the implementation of open source software into schools was explained. The data sources, including the major stakeholders in the case-study school and the documentation sources, were described. The population and recruitment considerations for participants in the case study were explained and the implications discussed.

The research methodology was described as a qualitative case study combined with a thematic analysis of data. Most data for the research were qualitative, but also some quantitative data were collected and analysed using spreadsheet software. I used case-study methodology to gain an understanding of how open source software is used within the school community and constructivist thematic-analysis methodology to develop models of implementation of the open source software in the senior high school.

The data-gathering methods included email surveys, interviews, focus groups, observations and web surveys and were informed by the case-study methodology. Informed consent was given by each research participant by reading and signing a participant information form which was made available before interviews and focus group meetings. The participant information form explained the reasons for the research, the measures taken to alleviate risks, the anonymity of the responses and the procedures for safe-guarding data.

Chapter 4 reports the findings of the research into open source software in the case-study school.

Chapter 4

RESULTS

4.1 Chapter Introduction

The previous chapter outlined the methodology used to investigate the implementation of open source software (OSS) to support learning and teaching in a New Zealand senior high school. Chapter 4 presents the results derived from relevant qualitative (narrative) data and quantitative (statistical) data. The results are organised around the key research questions that guided the research.

In this chapter, results of the case-study research regarding the factors that facilitate or impede the implementation of OSS are presented for the period between March 2013 and November 2013. During this period, data were collected via separate focus-group interviews of Year 11–13 students and one-to-one interviews with administrators, an IT technician, school management and teachers. A web-based survey was conducted with a sample of students attending the case-study school.

Findings are presented for each of the research questions. Relevant results for each research question are described as a clear narrative and contain "thick description" (Bloomberg & Volpe, 2012, p. 9). The views of different stakeholders interviewed and surveyed are presented in the context of qualitative results. Chapter 4 sequentially reports results for the questions which guided this research.

4.2 What is Open Source Software?

4.2.1 Section introduction

Hansen, Kohntopp, and Pfitzmann (2002) have provided a simple definition of open source software which contains all the essential characteristics (p. 461):

- *"The source code is distributed along with an executable program.*
- *It is free to use.*
- *It includes a licence allowing anyone to modify and redistribute the software."*

Open Source Initiative (2007, para. 1) has a more-comprehensive definition of open source software which includes:

1. *"Free distribution*
2. *source code availability*
3. *derived works (licence must allow for derived works)*
4. *integrity of the author's source code*
5. *no discrimination against persons or groups*
6. *no discrimination against fields of endeavour*
7. *distribution of licence*
8. *licence not specific to a product*
9. *licence not restricting other software*
10. *licence being technology neutral."*

4.2.2 Board of Trustees' (B.O.T) definition

In New Zealand, a school's Board of Trustees consists of parents who are elected to control its governance. NZSTA (2019, p. 4) states that the role of the Board of Trustees is to ensure that "every student at the school is able to attain his or her highest possible standard in educational achievement". In order to incorporate the use of open source software within a school, the support of the Board of Trustees is needed. The Deputy Principal of the school involved in this research was requested to send an email to members of the Board of Trustees and include a question about what open source software means to them. Two responses were received from the email request (one labelled B.O.T One and the other B.O.T Two):

> *Software that is both free of licensing fees and also able to be constantly developed by the user community.* (B.O.T. One)

> *Flexibility and a worldwide community working together to empower all users, not just those with wealth.* (B.O.T. Two)

The main issues identified in the statement by B.O.T One are cost savings for the school and that the software constantly is being improved by the open source community, with the improvements being directed back to the user of the software (the school). This means that the software is always being improved at no cost to the school and that improvements are made available to the school community on an ongoing basis with no cost.

A main issue identified in the statement from B.O.T Two is that the software is editable. If needed, the software can be further modified to suit the needs of the school. If the school improves the code and the usability, then improvements can be fed back to the open source user community for the benefit of all users. Access to open source software ensures that all students have equitable access to educational software (National Reading Association, 2008).

From a governance perspective, the cost factor is appealing to the Board of Trustees because any savings can be directed elsewhere in the school budget to benefit the teachers and students. B.O.T. Two also had a global perspective that development and use of open source software allow access to those students who cannot afford propriety software.

4.2.3 Senior management team's definition

Members of the senior management team interviewed included: the Principal; three Deputy Principals (Deputy Principals One, Two and Three); and Deputy Principal Four (the founding Deputy Principal who had left the school) who was instrumental in the original selection of open source software for the school. The senior management team use the open source software for administrative and teaching purposes. Some of the interview responses from the senior management team are reported below.

4.2.3.1 Principal's definition

The Principal was not concerned about the technical explanation of OSS (stating "I always say I know the least about it") and fully supported its inclusion throughout the school. Brannigan (2010, p. 2) stated that: "Leadership is one of several critical components in the successful integration of ICTs in Education. The locus of leadership influences the degree to which ICT integration can become embedded in educational institutions as well as the role of leadership in championing ICT."

The Principal stated that, “with open source, every student is going to have more access to programs that we otherwise couldn’t afford”. Access for all students to open source software, whether at school or at home, was important for the Principal.

The concept of ‘openness’ in the development of the new school was also a consideration for the Principal:

> *This is the way to go because it was the open access and we kind of have that as part of our thing; if it’s open access, it’s not open access to some, it’s open access to everybody.*

Also being aware of the cost savings with open source software, the Principal was very supportive of giving access for all students at school or at home:

> *When we started the school off, one of the things was about building relationships, that was our big thing, so what we had up on the whiteboard is whatever it needs to be to build a relationship rather than hold someone back. So, with the open source software, we could easily achieve this.*

4.2.3.2 Deputy Principals’ definitions

Deputy Principal One, who was responsible for the overall deployment of open source software within the school, stated that “open source software right through to free software must be basically useable by students for free on any computer they want, whenever they want”. Deputy Principal One also discussed that open source software has a source code that is available for people to change as they like and that, with open source software, there is freedom of access for everyone compared with proprietary software. “Commercial software may or may not do a better job but there are extra costs for them to use it.”

Deputy Principal One also mentioned that freeware software can also be used within the school if it assists students’ learning needs. “Freeware is copyrighted software that may be freely download, installed, used and shared. Users cannot modify the source code” (Technopedia, 2012, para. 1). If no open source or freeware alternative software is available for the learning needs, then proprietary software is used by the school in some circumstances. An example of this is the use of Final Cut Pro on the Mac suite for video editing purposes.

Deputy Principal Two stressed that open source software is non-proprietary and that there are “no costs associated with it, so that people can access it regardless of money, status or economic background." Along with the other senior management personnel, Deputy Principal Two thought that freedom of access to the software was important for students, stating that "it's basically free software, non-proprietary software, that's available at no cost".

The software is available to be downloaded and installed by anyone. If you wish to improve the software, the improvements are uploaded to the open source website and the improvements are then available to all the community: "It is community-owned software that anyone is able to download and install on any device that they have free of charge."

For Deputy Principal Four, freedom means that anyone has access to the software and is able to improve it for the good of the community. The free concept is not necessarily linked just to cost.

4.2.3.3 Summary of senior management team's definitions of OSS

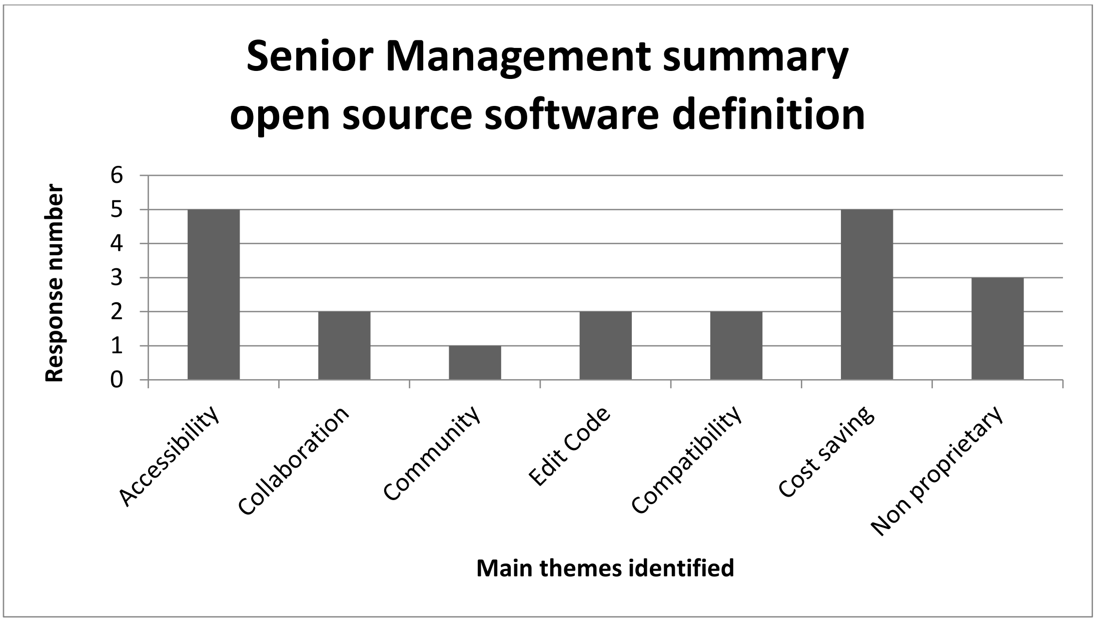

Figure 4.1: Main themes in senior management team's definition of open source software

By way of summary, the comments made by the three-person senior management team about open source software were classified into the main themes in Figure 4.1. This figure shows that accessibility (open source software is accessible to anyone regardless of income, education or occupation) was a major factor in defining OSS for Senior Management, whose aspiration was for software use at the school to be accessible. Cost saving also was a major factor, both for the school in providing software for educational needs and for student use of open source software on home computers at no cost. There is freedom to edit the software to tailor it for school and community use.

In summary, Senior Management had a good understanding of the definition of open source software in terms of both freedom of access and ease of modifying/improving it for the benefit of the open source community. Also freedom of access is important so that no-one is disadvantaged by being unable to use the software. Finally, the cost saving in accessing and using the software frees up funds for spending elsewhere in the school.

4.2.4 Teachers' definitions

Of 10 teachers who volunteered to be interviewed, five were male and five were female, which achieved gender balance. Each of the 10 teachers interviewed had a slightly different definition of open source software and was comfortable in providing a definition.

Teacher One emphasised that open source software has a code available to developers who are free to modify and improve the code. "People can take the software, develop it, take it where they like, create applications from the software." The software is free and you cannot charge for the software content. Teacher One viewed open source software as a good alternative to commercial software, which has little flexibility. Improvements to the software are shared with the user community, software can be personalised for one's own needs and it is cost free.

Teacher Two stated that open source software is "readily available, free to use, which enables users to share information freely without the costs of a licensing fee". Access to the software for everyone is important and its availability at no cost means that all students have ready access.

Teacher Three commented that open source software is "available and doesn't have to be bought, making it available and accessible by all without purchasing any license or anything to use it". This teacher considered that major factors were the low cost of OSS and that it is freely accessible by anyone without worrying about copyright or licensing.

Teacher Four liked being free from the corporate software. “You are not bound by the big boys, Mac, Microsoft.” But Teacher Four accepts that open source software has some bugs: “I would probably say that there’s a few hitches but that really depends on what you’re doing and how you approach it.”

Noyes (2012, p. 1) noted that a survey by Development Testing Firm Coverity revealed that “open source code has fewer defects per thousand lines of code than proprietary software code does”.

Teacher Five identified that “open source software is available for free online” and that it is always being improved, but isn’t quite up to the level of the proprietary standard. Teacher Five reasoned that the lag is because open source developers are not paid and give their time voluntarily. For Teacher Five, both concepts of being free are important: freedom to download and use the software; and the free cost of the software.

Teacher Six defined open source software as “free up-to-date software which allows collaboration and creativity”. Teacher Six also stated that open source software is:... ”like Linux in being more an open playing field for people to suggest ideas and share, and hopefully from that create, ideas which can be used basically by anyone”.

There is a community of practice around open source which encourages collaboration and shared development which benefits all the community of users. Teacher Six also was comfortable with copyright issues, with open source software being used by anyone without consequence.

For Teacher Seven, accessibility was a major factor (with OSS being easily accessible by everyone). Teacher Seven stated that there is wide variety of types of OSS available for education. Teacher Seven also identified that open source software is cost free to use and easily available to download. Teacher Seven used OSS extensively in her English programme and invited any teacher interested to talk with the school for further information and recommendations. Accessibility is a plus for Teacher Seven who found a wide variety of open source software available to support the English Curriculum.

Teachers Eight's definition was short and concise: "freely accessible generic type software". Teacher Eight stated that, if you don't have Microsoft Word, then there is a generic word processor available in open source that can replace it. Being cost free and easy to access were important for Teacher Eight and, if you identify a need in education, then you need to search for appropriate open source software.

Teacher Nine also compared open source software with proprietary software. "Probably very similar to the standard Microsoft where there's Word and PowerPoint and Excel but it's free to use and anyone can download it and put it on his/her computer." Similar to other teachers, Teacher Nine emphasised accessibility, compatibility and cost-free factors. Teacher Nine also stated that she does have some compatibility issues, but enjoys using it and doesn't have a problem with it in the school.

For Teacher Ten, free cost and copyright considerations were important. "It gives students the opportunity to bring in their own devices and download everything legitimately rather than plagiarising or acquiring programmes." Flexibility is also important because it gives students the ability to purchase their own device and connect to the school network. Open source software gives students freedom in choosing their device and also makes allowances for differences in learning styles. Teacher Ten also noted that the school was still adjusting to the open source software model.

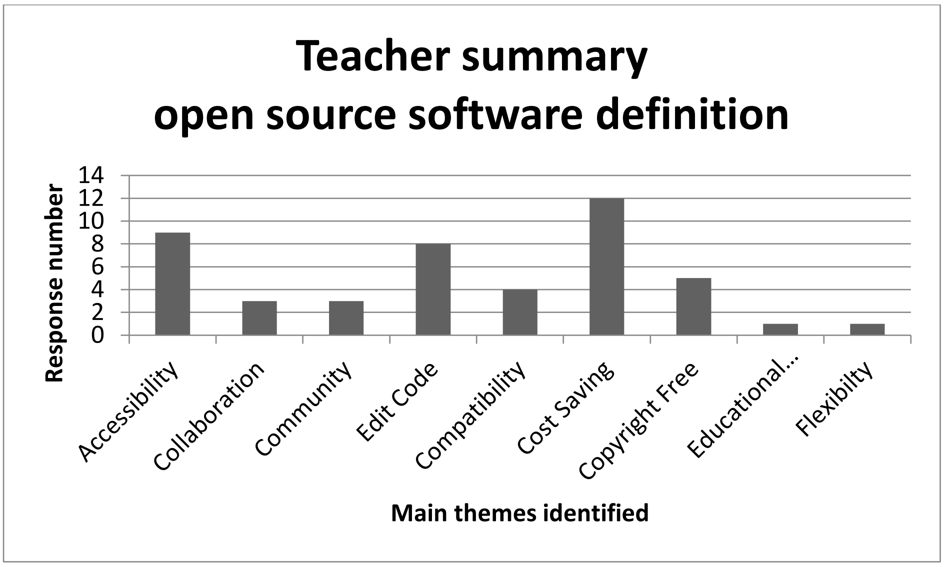

Figure 4.2: Main themes in teachers' definitions of open source software

Figure 4.2 shows that, for the teachers' definitions of open source software, being cost free dominated, with all teachers mentioning it during interviews. Cost savings are important for teachers because this means that there is more money from the school budget to spend on other curriculum areas. This is also closely related to the second most-important factor, accessibility, which is important for teachers because OSS is easily accessible by the students and teachers regardless of economic status. The copyright-free status of open source software means that students can use the software on their own devices without paying any licence fees and can access the school wireless network when undertaking academic tasks.

4.2.5 IT Technician's definition

The IT Technician identified open source software as being cost free, but also focussed on the ability to edit the code and share improvements with the open source community. "If you have a skill, ability, you can modify the source code and you can add your own features." With proprietary code being closed, you have to wait for someone in the software's commercial company to change the features.

4.2.6 Students' definitions

Student focus groups were conducted in the three year-level groups (Year 11, 12 and 13). The Year 11 focus group was interviewed in March and October, while the Year 12 and 13 groups were interviewed in April. Insights from focus groups are provided below.

4.2.6.1 Year 11 focus group (March and April)

In the initial interview (March), a male student identified OSS as "software for which anyone has access or can read the code". Another male student identified Linux as being associated with open source software and described OSS as "prototype software that has been used widely". A minority of students answered the question because most students were unaware of the meaning of open source software and did not feel comfortable about responding to the question.

Figure 4.3 shows that access to the software and the ability to edit it are important considerations in Year 11 students' definition. The open aspect, association with the Linux brand and the substitution for Microsoft are also relevant.

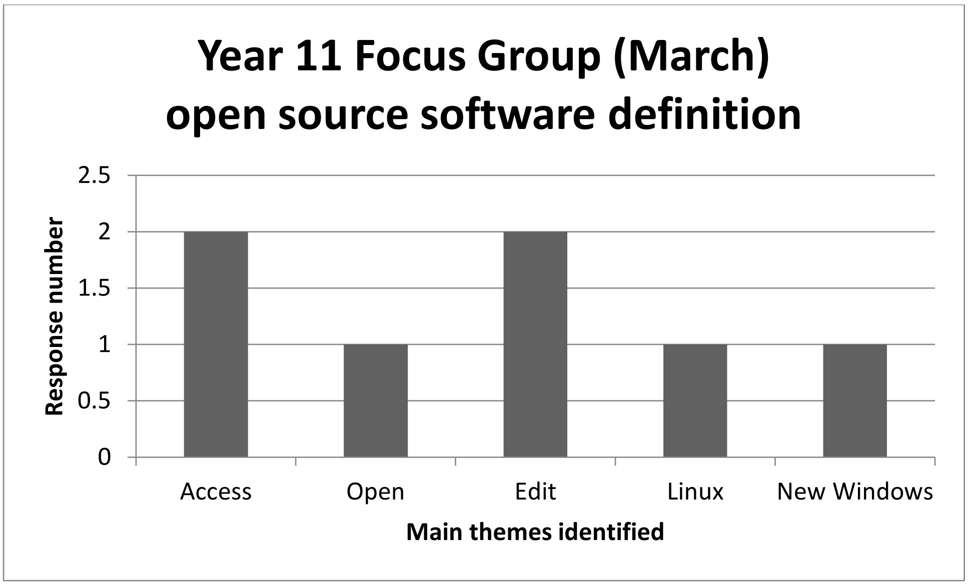

Figure 4.3: Main themes in Year 11 focus group's (March) definition of OSS

In the second interview (October), males again were the only students to answer the question regarding the meaning of open source software. The two male students stated that "it is not closed, it is free, it is open" and that "anyone can access it, they can edit it in any way they want, its open source meaning that the source code is open to people". Students also likened the software to Microsoft Windows: "It's a new Windows but more open." The majority of the students were very reticent regarding the meaning of open source later in the interview and they were aware that it is different, but unaware of its exact meaning.

Male students who responded to the question gave accurate answers regarding the meaning of open source software, but they did not represent the views of the many students who were not sure of the meaning. There also was little change between the answers given in the March and October interviews. Female Year 11 students were very quiet and did not offer any views about the meaning of open source software. Male students stated that open source software is open and free. The source code is available for editing in any way that a person wants. Access is important so that anyone can access the software and the source code. The concept of 'free' referred to freedom for anyone to use or modify the software.

Figure 4.4 summarises the main themes in the definition of open source software identified by the Year 11students who responded. The main themes concerning the open nature of the software and the ability to edit the source code have been covered above. The freedom theme also was introduced in the second interview. Overall, there was little change from the initial interview in March apart from the themes identified being smaller in number.

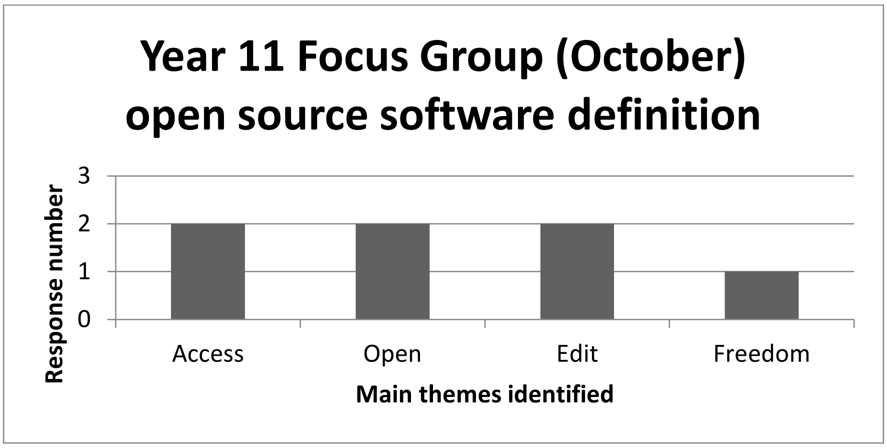

Figure 4.4: Main themes in Year 11 focus group's (October) definition of OSS

4.2.6.2 Year 12 focus group interview (April)

Year 12 focus group interview responses about the definition of open source were dominated by male students. Three female students responded with "I don't know what it is", "I don't know what it is either" and "I doubt if I would know". Miliazewska and Sztendur (2010, p. 238) found in their literature review that "in general, girls tend to report lower levels of interest in computers and lower levels of confidence in their abilities".

In general, the male students who responded indicated they had a good understanding of the meaning of open source software, especially that it is free (meaning no cost associated with its use). Accessibility was a strong theme, with a male student stating that it is "software which anyone can have, it is mostly used for non-commercial stuff, anyone can edit and change it". This male student also stated that the open source software is very accessible and is available for editing in order to customise it for the user. The third male student also emphasised accessibility stating that it is "software that is free for anyone have and use". Freedom here refers less to financial cost and more to access for anyone to use it.

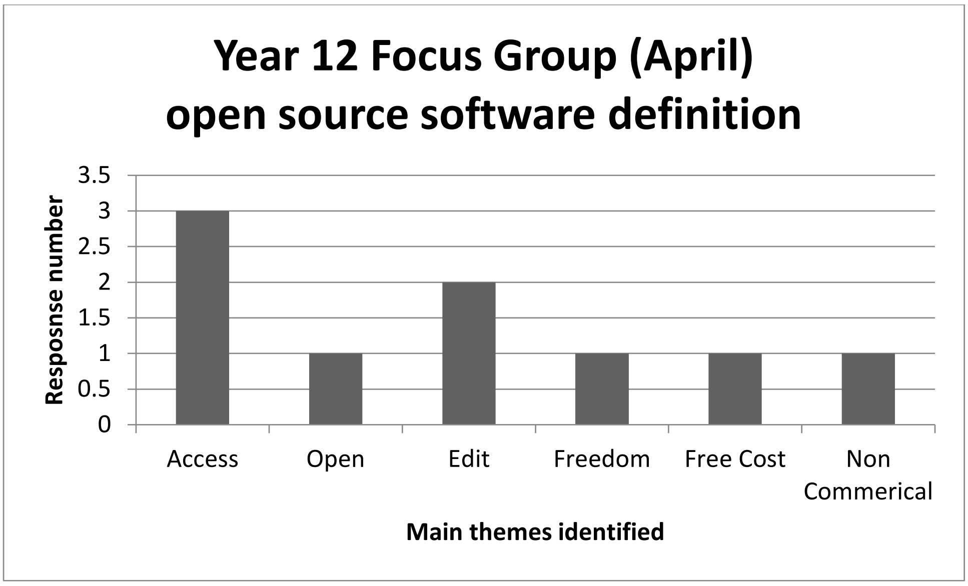

Figure 4.5: Main themes in Year 12 focus group's (April) definition of OSS

The summary of themes in Figure 4.5 reflects that accessibility of open source software is important for males in defining it during the Year 12 focus-group interviews. The ability to edit the source code to customise the software for the user also was important in their definition. The focus group also defined open source software as non-commercial as opposed to commercial or proprietary software. The males in the group mostly contributed to the definition of open source software, while the females did not offer any suggestions.

4.2.6.3 Year 13 focus group (April)

The main difference in Year 13 students, responses is that both male and female students had equal input into the definition. A male student stated that "it is software that is free to download and use. And quite often you can view the source code for the program." A female student stated that open source software is accessible to people inside the school and outside the school. "Someone from outside the school can get the program as well. It is not confined to the school." Another male student stated that anyone can not only view the source code, but also modify it to suit his/her needs. A female student defined open source software as cost free and added that this meant that the school could spend the cost savings in other areas.

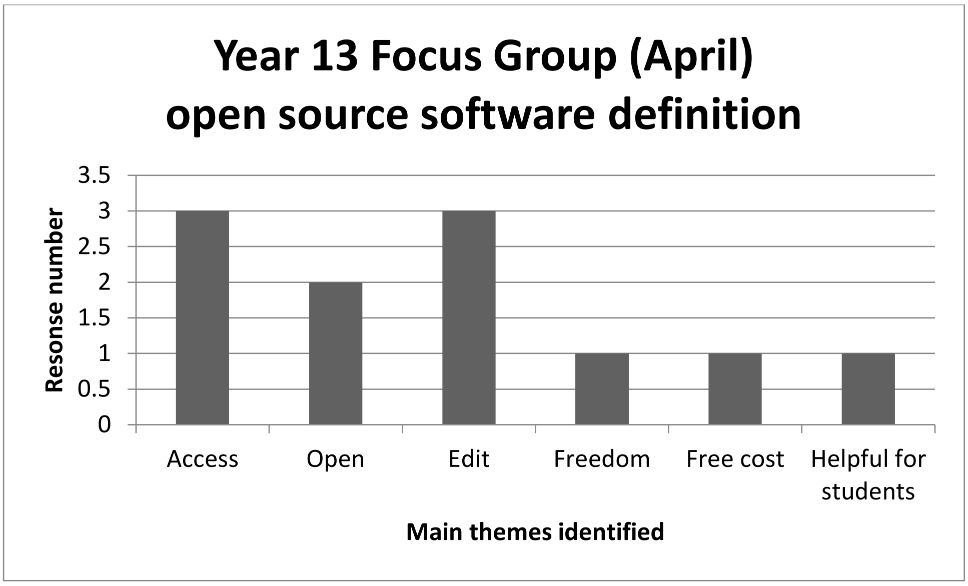

Figure 4.6: Main themes in Year 13 focus group's (April) definition of OSS

The summary of themes in Figure 4.6 suggests that both male and female year 13 students defined open source software as being accessible by everyone and with the source code open to view and edit to suit the users' needs. A student stated that "you can change the source code to suit your needs".

Students were very vocal and confident in their definition of open source software. With this being the third year during which they had been exposed to OSS, both freedom to use it and its free cost were aspects of their definition. The free cost was further defined by stating that it allowed the cost savings to be used elsewhere in the school. A female student stated that "it is free and so it cuts costs for the school and that money can be used for other things". Year 13 female students were much more confident and knowledgeable in discussing open source software than Year 11 and 12 female students.

4.2.6.4 Online student survey

When an online survey was made available to all students in October 2013, 93 students responded out of a total of 700 (13%). Nulty (2008, p. 302) states: "In general, online surveys are much less likely to achieve response rates as high as surveys administered on paper–despite the use of various practices to lift them." The survey was distributed to students through an online link to Survey Monkey provided by the Deputy Principal to Year 11, 12 and 13 students.

Figure 4.7 shows that there was an even spread of Year 12 and Year 13 students who participated in the survey, with fewer Year 11 students. In terms of the *gender* of students who participated in the survey, Figure 4.8 shows an even spilt, with males making up 47% while female participation was 53%. This is a representative sample of the student population.

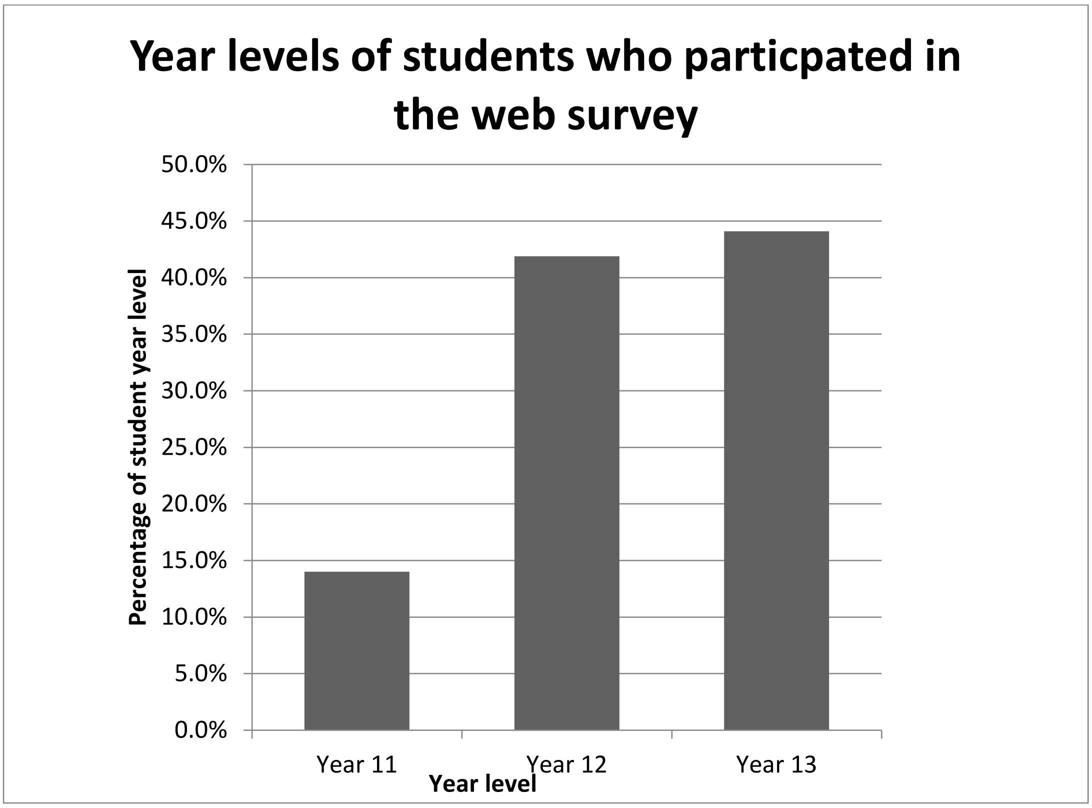

Figure 4.7: Year levels of students who participated in the web survey

Students were asked in the web survey: “What computer operating system do you use at home”? The responses summarised in Figure 4.9 illustrate the dominance of the Microsoft Windows operating system (84.8%). This was followed by the Apple Mac operating system at 23.9%, with OSS used in 6.6% of student homes. A New Zealand survey of operating systems by Quin (2010) revealed the use of Microsoft 92%, Apple 5% and Linux 2%. The senior high school survey reported Linux in 6.5% of the student homes which indicated that attending the high school might have influenced the selection of some home computer operating systems. Table 4.1 illustrates the differences in computer operating systems between the two surveys. The senior high school was located in an area in which 3% of homes had no computer.

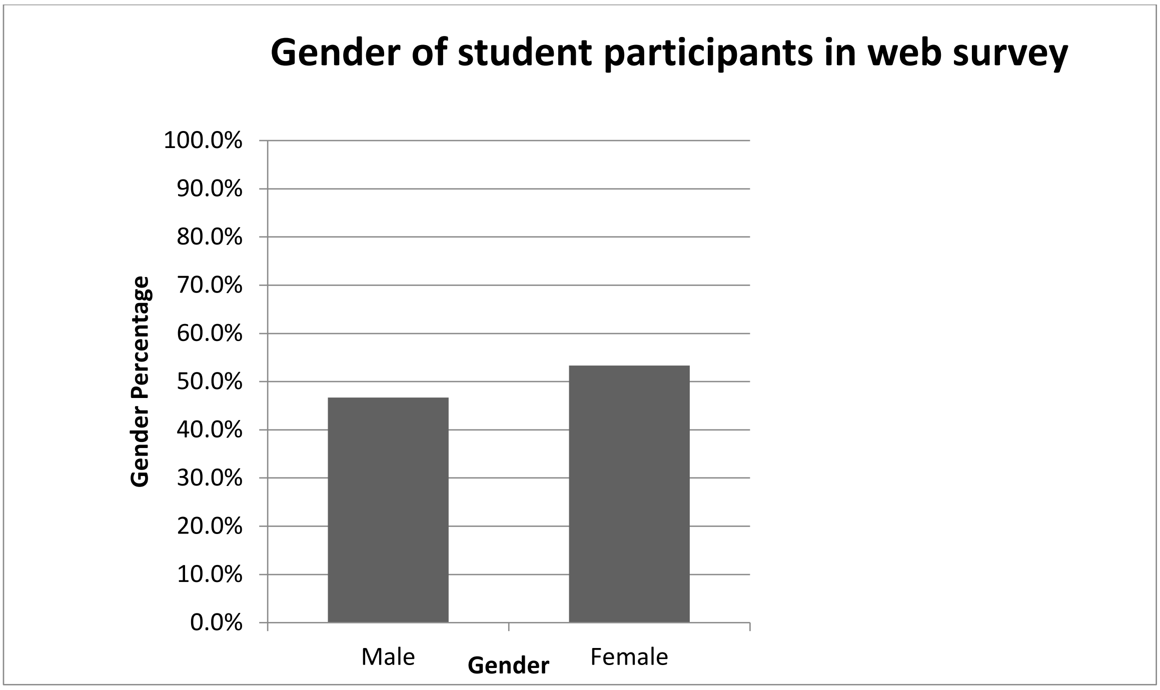

Figure 4.8: Gender of student participants in the web survey

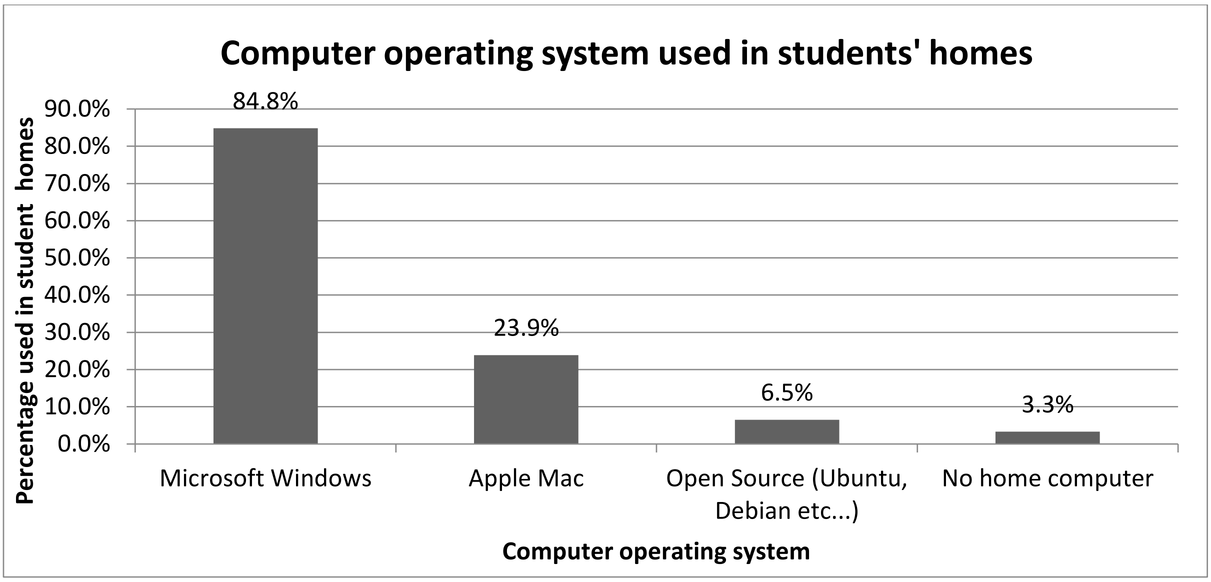

Figure 4.9: Computer operating systems used in students' homes

Table 4.1 *Comparison of my study's web survey and 2010 NZ computer crime and security survey in terms of percentage use of different computer operating systems*

Computer Operating Systems	Linux	Microsoft	Apple
2013 Web Survey (current study)	7%	85%	24%
2010 NZ Computer Crime and Security Survey (Quin, 2010, p. 12)	2%	92%	5%

When students were asked if they brought their own device (e.g. laptop/tablet/telephone) to school to help their learning, most students (87%) responded that they brought a portable laptop/tablet/smart telephone. This reflected the school's open policy in allowing students to bring their own devices to school and encouraging the integration of these devices into the student learning activities. Figure 4.10 illustrates the large percentage of students who brought their own devices from home to connect to the school's Wi-Fi network.

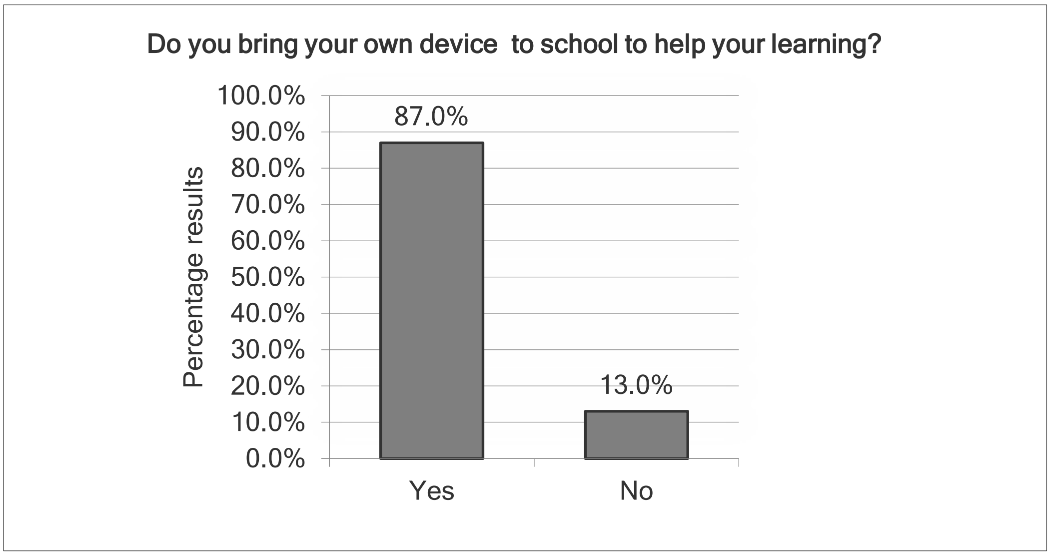

Figure 4.10: Percentage of students bringing their own device to school to help their learning

Next, students were asked what specific device(s) they bring to school to help with their learning. Figure 4.11 shows that most students had smart telephones that they brought to school to use the apps that support learning in the classroom. Many students bring more than one device to school to use to suit the learning task. All devices had WiFi capability and 97% of students brought a portable device to school.

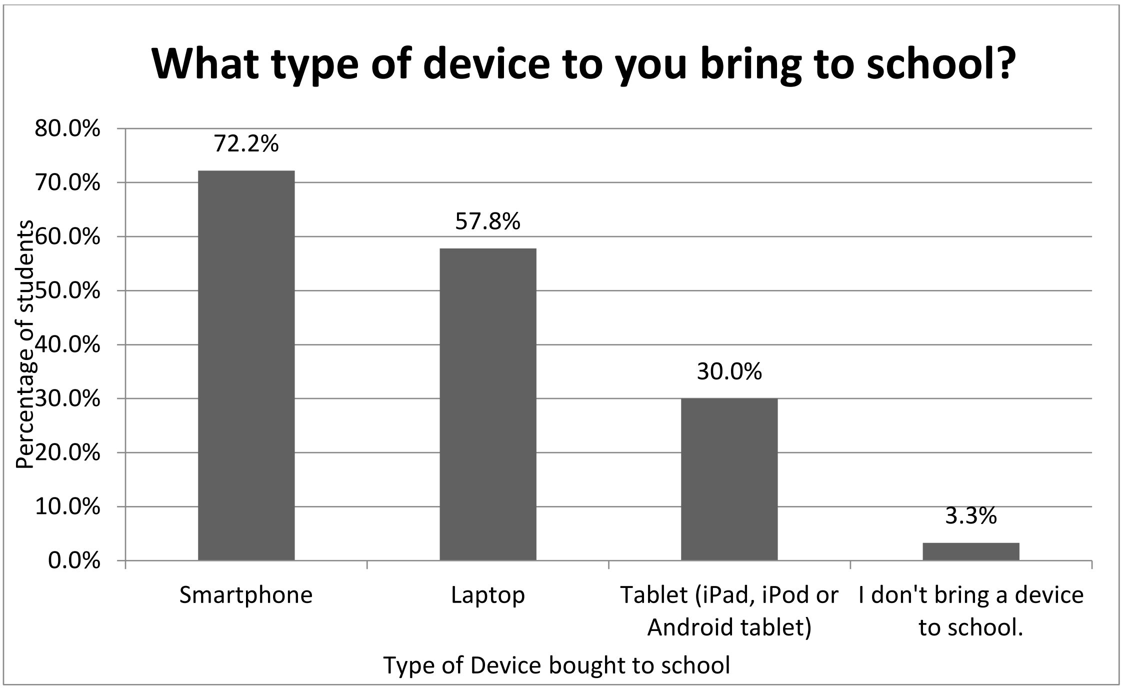

Figure 4.11: Types of devices brought to school

4.2.6.5 Web survey: Definition of open source software

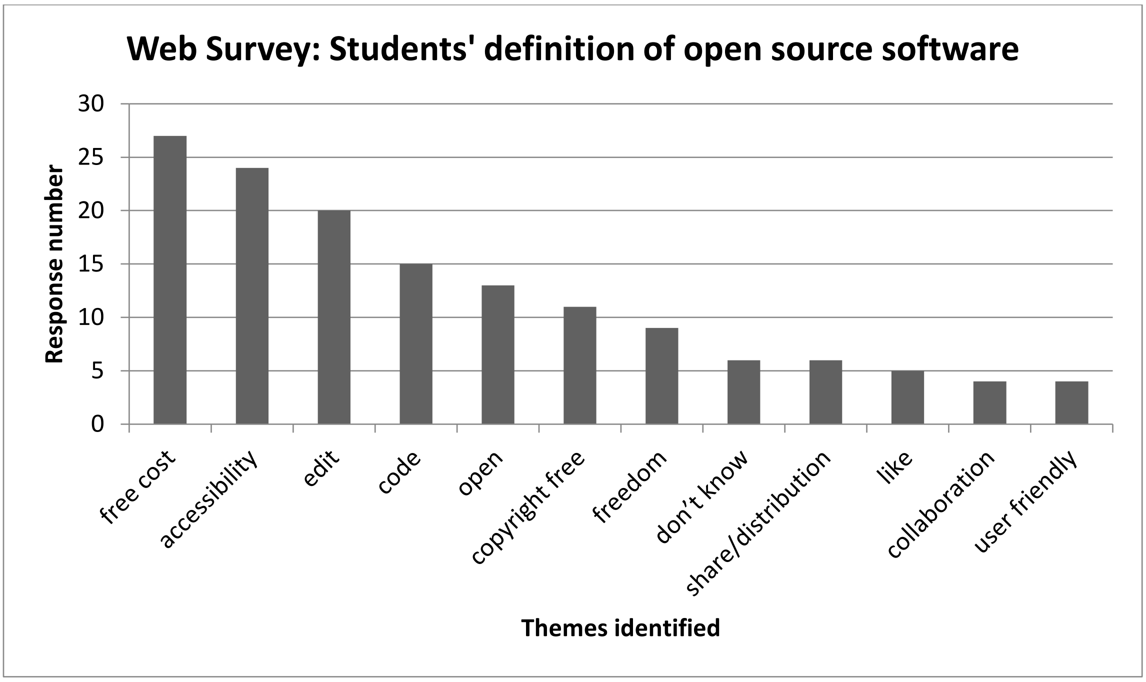

Figure 4.12: Web Survey: Summary main themes in students' definitions of OSS

The first survey question was: "In one sentence define open source software." Figure 4.12 shows that the major themes identified by the students were cost, accessibility, editing code and openness. These themes are consistent with the definition of open source software of Hansen, Kohntopp, and Pfitzmann (2002). The students' definition is from the school context. An example of this is the frequency of the theme concerning the free cost of OSS. The freedom of access was identified along with the ability to edit the source code to customise the software and feed the improvements back to the open source community. The open source license means that anybody can access and use the software.

4.2.7 Conclusion: Definition of open source software

A wide variety of interpretations of the meanings of open source software was found among the stakeholders. Generally, most adults identified the main attributes of open source software, whereas the students identified a narrower range of attributes. In the focus groups, particularly year 11, students had limited understanding of the attributes of open source software. Male students were more confident in discussing attributes of OSS, with the level of understanding increasing throughout the year levels for both male and female students. Understanding of the meaning of OSS was grounded in the context of education and the availability of educational software for all relevant stakeholders.

4.3 What are Rationales for Use of Open Source Software?

The eLearning section of Albany Senior High School (n.d.-c, para. 1) website states:

> *Our vision for technology at ASHS centres around the role it can play to achieve our vision: to nurture, inspire and empower students to achieve highly and become good citizens. As a result, we have put together a range of ICT tools and environments that help our staff and students to achieve our vision. We are an open source school, which means we can offer our students a wide range of powerful tools without encountering the problems that come with proprietary software.*

The school's vision is to develop citizens who can reach their potential and contribute to New Zealand society. Open source software tools and open learning environments were components of the schools' vision because OSS can be freely downloaded and installed on any number of school computers without the licensing restrictions of proprietary software. Access for all students is paramount in this school. Albany Senior High School (n.d.-c, para. 3) website also states: "Students are able to bring notebook computers for use in class, and the school provides lockers for security and access to our wireless network".

Openness was an important part of the eLearning vision. Students are welcome to bring their own devices with a variety of operating systems and connect to the school network. The school is open in many other ways including architecture, teaching spaces and pedagogy.

Twining (2014) compiled a list of rationales for the use of ICT in education that justify the use of OSS at the senior high school:

1. Social. "As preparation for living in a society that is permeated with technology" (para. 15)
2. Vocational. "As preparation for work" (para. 16)
3. Economic. "In order the support and stimulate the country's economic development" (para. 17)
4. Marketing. "In order to impress stakeholders (e.g. inspectors, funders, prospective parents/students)" (para. 18)
5. Cost effectiveness. "In order to increase productivity of education and in order to reduce the cost of education" (para. 10 & 11)
6. Transformation. "As a catalyst for educational change" (para. 5)
7. Pedagogical. "In order to extend and enrich learning across the curriculum" (para. 3)
8. Bridging the digital divide. "To reduce inequalities between students/pupils with differential access to ICT outside formal education" (para. 19).

These rationales guided the selection of codes for analysing stakeholders' responses to the rationales for using open source software. Sections 4.3.1–4.3.5 present the rationales for the use of OSS for learning and teaching by the stakeholders in the school (namely, Board of Trustees, Senior Management, Teachers, IT technician and students).

4.3.1 Board of Trustees (B.O.T.) rationales to using open source software in the school

When Board of Trustees members were asked via email about their rationales for the use of OSS in the school, B.O.T. One stated that "software is constantly under development”. This ensures the currency of software and that benefits are passed on to the students via the user community. B.OT. One also stated that the software was free to use. B.O.T. Two stated that the software was free to use within the school and that a benefit was that “we that can use our funds for much more meaningful learning tools/experiences”. Another reported cost saving was the lack of virus issues.

B.O.T. Two also described some pedagogical benefits. “It allows students to engage with and use confidently a wide range of software types.” Flexibility was another key factor because the school was not locked into using one type of software because of financial investment.

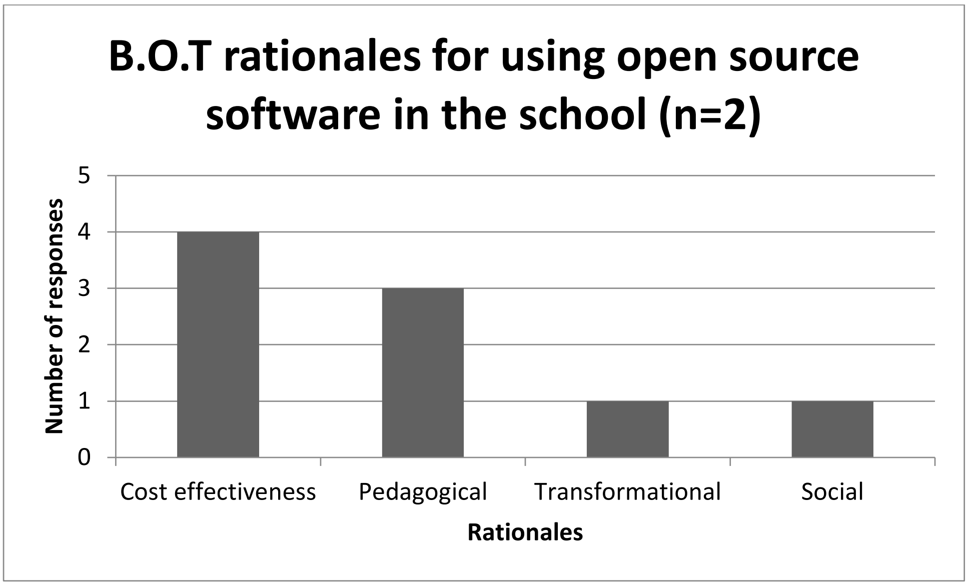

Figure 4.13: Frequency of Board of Trustees’ rationales for using open source in the school

B.O.T. responses were coded according to their link to Twining’s (2014) rationales. Figure 4.13 shows that, for the B.O.T., cost savings for the school were very important for freeing up funding for benefit students in the school. Pedagogy was also important for allowing students to engage with their learning and choose between a wide range of software to support their learning. OSS was also a good fit to the culture of the school which was viewed as progressive and community minded (transformational rationale).

4.3.2 IT Technician's rationales for using open source software in the school

The IT Technician did not want to be locked into the use of software because the school had invested money into proprietary software. The main advantage of open source software was seen as freedom to choose and modify it to suit the school's needs if required. Every student can use the software at home without licence fees or software piracy issue. The school also had the freedom to choose the most-suitable software for the specific curriculum area from the OSS database. The IT Technician stated that "we just wanted to get rid of those proprietary things like being locked into a particular vendor".

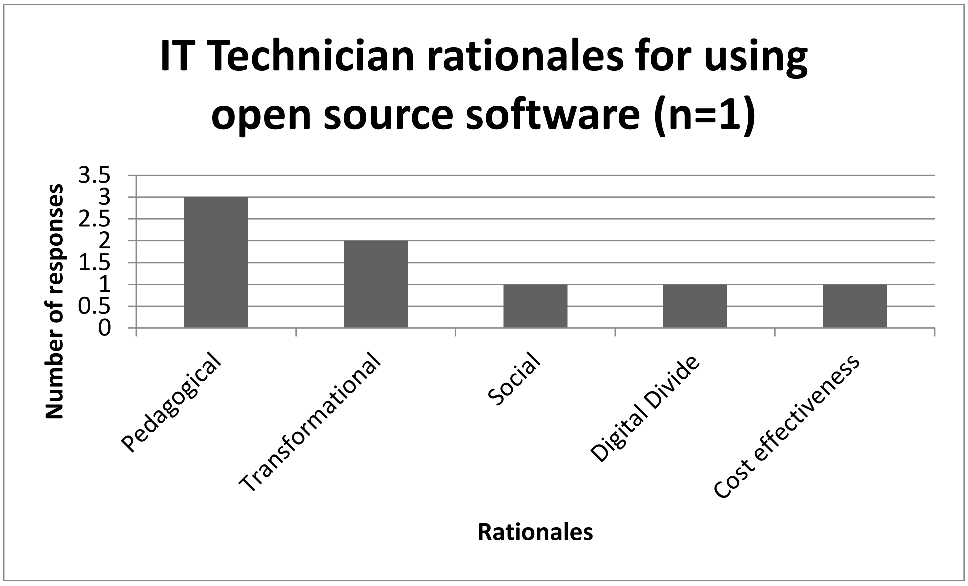

Figure 4.14: Frequency of IT technician's rationales for using open source software

During the interview, the IT technician's responses mostly fitted into the pedagogical and transformational category in viewing OSS as consistent with open access to support student learning in the school and at home. The digital divide rationale of Twining (2014, para. 19) involves reducing inequalities between students with differential access to ICT outside formal education". Figure 4.14 illustrates the high frequencies of B.O.T.'s pedagogical and transformational rationales for the selection of open source software for the school

4.3.3 Senior management team's rationales for using open source software in the school

Senior management personnel were asked two questions. First, how does the open source software philosophy fit in with the school vision? Second, why are you using open source software in your school?

4.3.3.1 Principal

The principal wanted the choice of software for the students to be open, not closed:

> *If kids want to do something, we want them to be able to do it without this kind of closing down. Oh, you can't do this because, you can't do this because, you can't do that because. That what happens in most schools in my experience.*

By removing the barriers to software choice, the principal wanted to allow students to choose the software to support their learning. The school had an open philosophy that was embedded in the schools' culture, with student choice and a student-centred philosophy being paramount. This applied not only to choosing OSS, but also to all areas of the curriculum. The principal stated that "there's no impediment and that is our philosophy right through the school and having open access for every student is exciting".

4.3.3.2 Deputy Principals

Deputy Principal One stated that "we really want students to be able to access learning wherever they are, whatever they are doing and whatever context they are in". Open source software choice and availability allowed students to reach this goal. Deputy Principal One also explained that the use of open source software allowed teachers to focus on the learning goal/idea rather than the technology:

> *We really want students to have access to the knowledge that sits behind that. It gives a chance to focus our teaching, as much as we can and as much as it is helpful for students, on concepts and ideas and ways of doing things rather than use of this single process in this particular piece of software. That's what we are teaching you to do.*

Deputy Principal One explained that software skills are generic and transferable into learning. Access to the appropriate software in a 'just in time format' is important, as is being able to select the appropriate software to assist with current learning. Cost is another rationale: “we’re not locked into spending money, a lot of money, on something that we don’t necessarily have to pay for.”

Deputy Principal Two considered that access to learning is important and that there should be no barriers to learning: “In our values in this idea of access to learning, there should be no barriers to access to learning and money shouldn’t be part of it.”

Because open source software is free, the cost barrier for the school and students is removed so that students could use it freely at home as well as school. Open access also applied to student personal devices and so students had the freedom to bring their own device to school and connect to the school network.

Deputy Principal Two stated that proprietary software had open source equivalents which had similar capabilities which were available to all students and teachers. This Deputy Principal also believed that generic software skills are transferable between open source and proprietary software.

Deputy Principal Three believed that learning should be student centred and that the use of OSS meant that all students had free access to software and the choice to install it on a personal device. “We strongly believe that you shouldn’t be disadvantaged regardless of where you come from and your socioeconomic status” in terms of access to software for learning. Deputy Principal Three was unsure of the financial benefits because the Ministry of Education pays for license fees for any Microsoft and Apple software used in a school.

Deputy Principal Three asserted that open source software was a good fit for the school vision and open philosophy of teaching:

> *We are trying to be collaborative in our teaching and de-privatising the practice. It is important that we walk the talk regarding open education philosophy and the integration of open software into teaching practice.*

Deputy Principal Four (the founding DP) explained the process that the school went through in the initial setup of the new senior high school. Senior management had researched student-centred teaching practice and referred to *Catching the Knowledge Wave* (Gilbert, 2005). This Deputy Principal stated that, because “the book about how important it is for knowledge to be an active verb, students build, make and do things with their knowledge”. Learner-centred, active learning is built into the school philosophy of equipping students with open transferable digital tools to use in their learning and life for the next 50 to 60 years.

Deputy Principal Four described the traditional way in which schools fund software:

> *With site licences, you pay a certain amount and store a copy of that software on every computer that the school owns. We realised when setting the school up that the cost of mobile devices was plummeting and we planned to let students to bring their own their own devices into the school.*

However, site licences do not allow students to install the software (e.g. Microsoft Office) on their own device (laptop, tablet or smartphone).

Deputy Principal Four also referred to Wiley (2010, 3:01) from the open education movement who stated that "without sharing there is no education". "Educational content should be freely developed and shared in a spirit similar to open source software" (Caswell, Henson, Jensen & Wiley, 2008, p. 2). This Deputy Principal stated that open source "facilitated sharing, collaboration and working together on learning". The philosophy behind the OSS movement was a good fit for the school philosophy to nurture, inspire and empower.

4.3.3.3 Senior management rationale summary

Figure 4.15 shows that pedagogy dominated the senior management's rationales for the use of OSS in the school, which fits in with the vision statement for the school to nurture, inspire and empower students. The senior management saw OSS as a match for the student-centred, authentic, active learning intended in the school learning programmes. Open access to software was important for removing a barrier to learning for all students in the school: students were not restricted to using specialist software through cost. Senior management also saw the potential of OSS for transforming learning by giving students easy access to appropriate software to support their learning when needed.

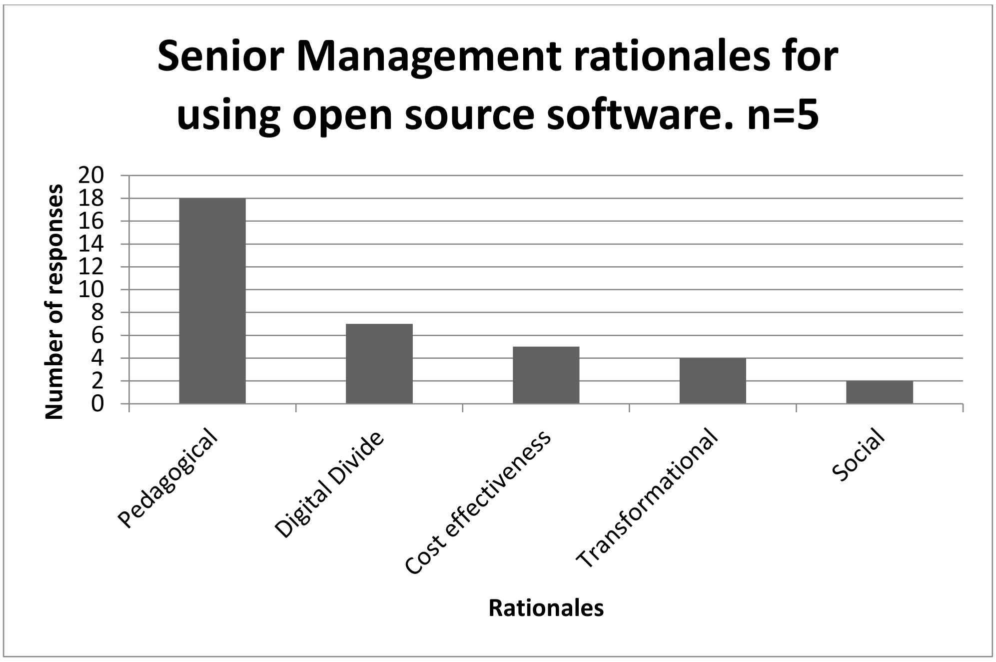

Figure 4.15: Frequency of senior management's rationales for using open source software

4.3.4 Teacher rationales for using open source software in the school

Teachers were asked why they were using open source software in their school.

4.3.4.1 Teacher One

Teacher One stated that cost savings were one of the most important reasons for using open source software throughout the school. Teacher One explained that, with proprietary software, "users don't realise that they don't actually own the software; what they're actually buying is the right to use the software". At the senior high school, OSS was deployed to all the students at no extra cost and was updated more regularly than proprietary software.

4.3.4.2 Teacher Two

Teacher Two mentioned that OSS being free was a major advantage for the school. Open access to the software was also important because students accessed it from anywhere on the school network and could install the software on their own devices. Teacher Two stated: "you don't have to be logged into your computer, and you can be logged in pretty much anywhere to use it. I find it really user friendly and also, in terms of collaboration, it is really easy to use that way as well."

4.3.4.3 Teacher Three

Teacher Three was very negative about the benefits of open source software for his classes, and did not view it as useful for preparing students for using software in their future workplace. This teacher argued that teachers should be introducing current industry standard software to students. "As someone who wants to teach my students and make them ready to go out and work…, the open source does not offer the best advantages."

4.3.4.4 Teacher Four

Teacher Four stated that teachers do not know what software students will be using in the future. "We don't know what our students are going to need in the future. and so who's to say Apple is the best or the Microsoft suite is best; open source is free so that all people can access it." Teacher Four also stated that, because there are open source equivalents of proprietary software that students can access, "maybe it doesn't specifically matter whether it's Adobe Photoshop or an equivalent in open source".

4.3.4.5 Teacher Five

For Teacher Five, availability and accessibility were important considerations for software in the school. OSS is readily available to be installed on the student devices and on the school computers with no restrictions. The use of OSS also narrows the digital divide: "It stops the restriction from people with limited budgets from being able to participate in photography and design when programs cost a lot."

4.3.4.6 Teacher Six

Teacher Six identified the two major rationales of cost saving and pedagogical aspects. Because OSS is free for any user and is updated regularly at no cost, all students have equal access to it. Teacher Six outlined pedagogical advantages of OSS: "It should be intuitive so that it's clearly easy to use for people, like an ePortfolio for which people can get an understanding of best practice." Teacher Six also stated that OSS fitted with the open philosophy culture within the school. "The school itself is like the software: open, collaborative, engaging and updated."

4.3.4.7 Teacher Seven

Teacher Seven saw that the two main benefits of OSS in the school were cost savings and access for students. "I come from a school where I know there was a huge amount of money spent on software licenses." Teacher Seven also reasoned that "we can be good guardians of public money actually in terms of how we're using that, and I think that's really important". Teacher Seven also considered important the accessibility for all students to the software for learning without any financial barriers. "It means that you don't need to be an individual student with money behind you to access learning."

4.3.4.8 Teacher Eight

Teacher Eight liked the open philosophy of open source software and that it was not tied to a duopoly such as Microsoft or Apple. "It seems to me a perfectly functional, accessible and democratised way of gaining those tools so to speak." The software is free to download in terms of cost and access. Teacher Eight had OSS installed on his personal MacBook and stated that "I can still access and amend all my documents and so forth from school in that respect".

4.3.4.9 Teacher Nine

Teacher Nine reasoned that, because OSS saves the school money, it allows spending on extra technologies such as extra computers. Teacher Nine also thought that it was beneficial for students to learn using alternative software. "It's good for them to use something other than what they might have grown up using."

4.3.4.10 Teacher Ten

Teacher Ten explained that the open philosophy of the school was demonstrated in the use of OSS for learning. It was a point of difference for the school and was part of the schools' identity. Teacher Ten was aware of the open source equivalents to proprietary software, such as Photoshop, and was excited that these can be used to support personalised student learning:

The philosophy was that students had ownership of bringing in their own devices and it was really to direct their own learning rather than the school saying you must have this, you must have that, this is the way we do things. It's actually putting the ownership back on the students to choose what suits them, which I liked.

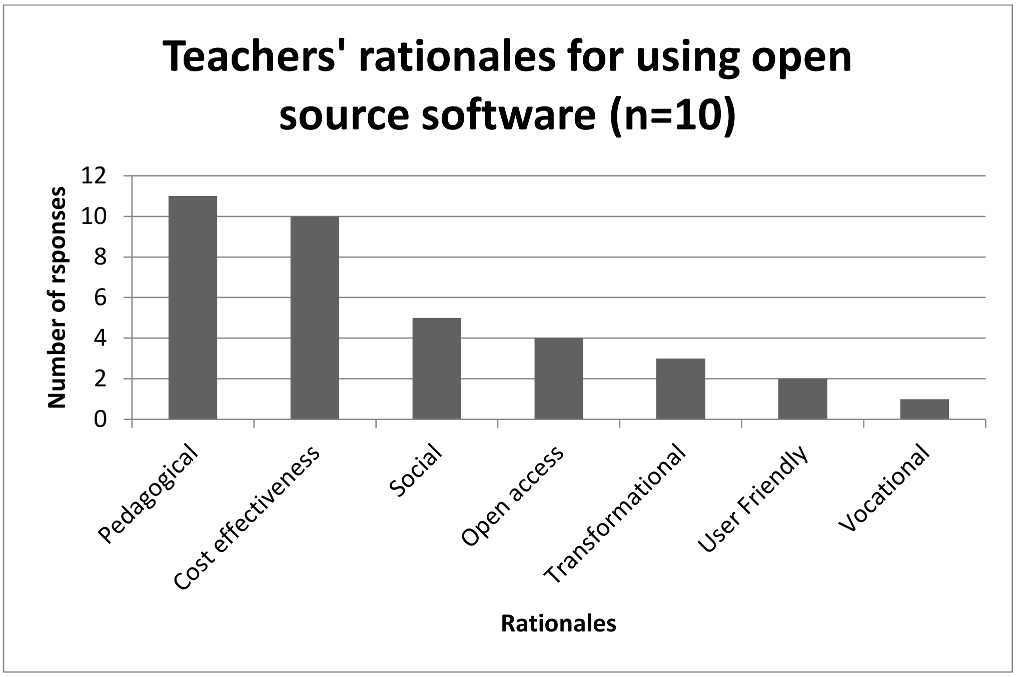

Figure 4.16: Frequency of teachers' rationales for using open source software

4.3.4.11 Summary of teachers' rationales for OSS

For the 10 teachers whose interviews are reported above, Figure 4.16 shows that pedagogy was a strong consideration when using OSS in the senior high school, with 11 mentions during the interviews. Teachers stated that OSS fitted in well with the open philosophy of the school and its student-centred pedagogy. The free cost meant that the school was not restricted in the software that it could use and the number of computers onto which it was installed. This meant that the software was freely available to all students and staff and was also preparing students for living in an open society with open access to software for everyone. A new rationale was introduced, with two teachers saying that OSS was user friendly and enhanced learning at the school.

4.3.5 Student rationales for using open source software in the school

Students were asked in the web survey for their opinion about why the senior high school uses open source software. Figure 4.17 shows that 41 students viewed cost effectiveness as being an important rationale for the decision to use OSS. For example, "because it's cheap, because it is free, save money for other departments without losing any usability, cheap and cost effective, to save budget". Twenty-six mentions in the web survey indicated that students also thought that the use of the OSS supported their learning both within the school and at home:

> *To make learning easier, to have a variety of software to accommodate students' preferences, to widen the learning for the students, so we can access similar files and easily share with each other, to expand the learning and develop our skills, to make it easier for students (learning, sharing information, etc…)* to use *technology to help students learn in a different way.*

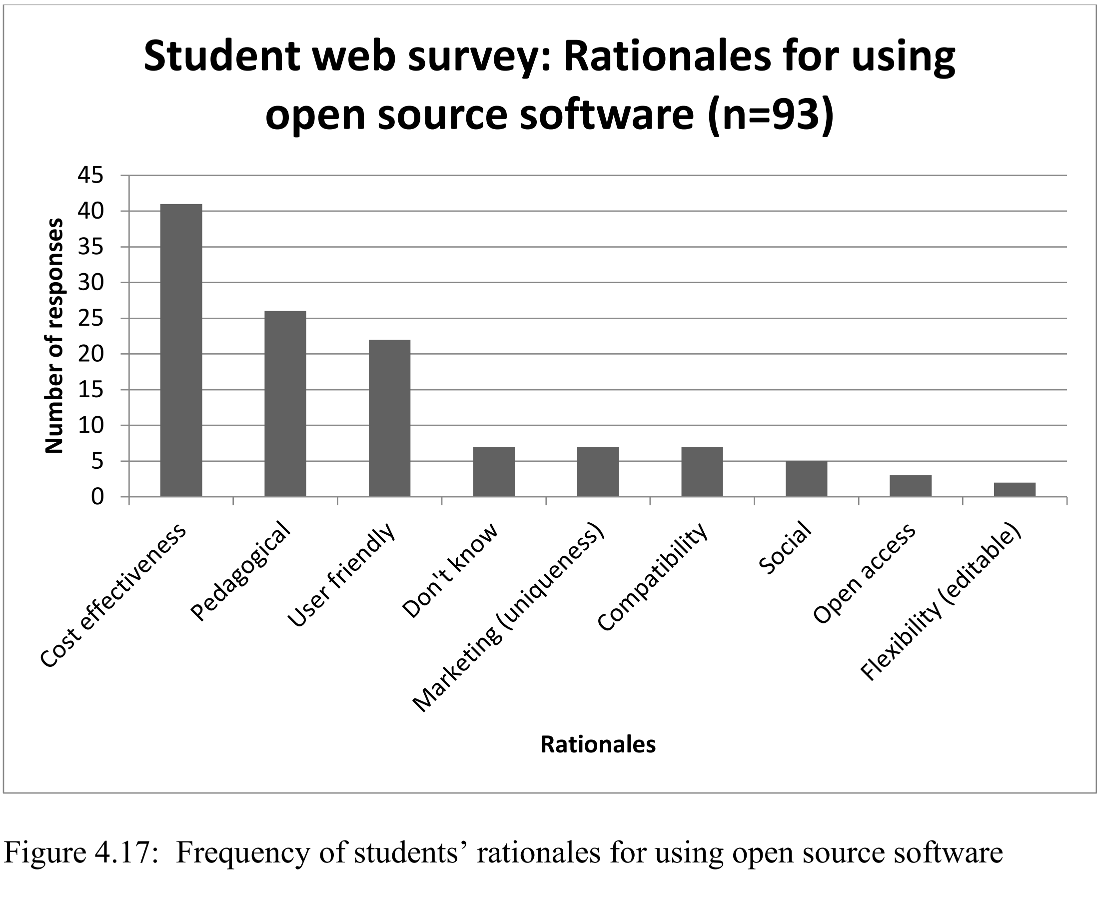

Figure 4.17: Frequency of students' rationales for using open source software

Twenty-two student responses identified user-friendliness as a rationale with comments such as "it's easy for students and teachers", "makes things easier for everyone", "simple to run", "easy to use and share information between all people" and "makes it easier for students to get their work done".

Compatibility was also given as a rationale, suggesting that OSS had the same capability as proprietary software and was suitable for supporting student learning:

> *This is a great way to get functionality without spending money on software or operating systems". It is accessible through all platforms, cost is far lower than something which may do the same thing, and why pay for Windows when you can get similar features through open source.*

In six responses, students identified the use of OSS as a point of difference for a senior high school perceived as technologically/advanced. A student stated: "The school is unique in many aspects, and I guess that using open source software is another unique part of school culture, because the school wants to be different and more advanced."

Five student responses identified the use of OSS as preparation for living in a society where technology for sharing and collaboration play an ever-increasing role. Comments included "it's the future of education", "share information between all people", "share documents between students and teachers", "easily share with each other" and "socialise with friends".

In summary, most students supported the use of OSS within the school with rationales similar to those of Twining (2014). Cost effectiveness was a common rationale, together with freedom of access meaning that the school and students were not restricted in the choice of software to support learning. Pedagogy was also a common rationale, with students perceiving that access to OSS was linked to supporting flexible learning within the school.

4.4 What are Advantages and Disadvantages of OSS in Educational Context?

There is much debate over the pros and cons of using open source software in education (Henderson, 2005), with schools which use it recommending it (Coddington, 2009). Penn Manor High School, which issues all middle and senior students with an Edubuntu Laptop, justified its choice to the parents in terms of OSS reducing acquisition costs and promoting flexibility in installing programs and storing local files (Reisinger, 2015a). Alternatives such as Apple computers, Microsoft computers, Chromebooks and tablets were all ruled out as being too expensive to purchase and maintain (Reisinger, 2015a).

In New Zealand, the majority of schools use proprietary software supplied at no cost by Microsoft and Apple under the Software Agreement (Ministry of Education, 2014). Google Apps for Education is available to all New Zealand schools at no cost (Te Kete Ipurangi, n.d.). Other than the cost-free aspect, schools also use proprietary or SaaS software because of service and support, security and usability (Pankaja & Mukund, 2013).

4.4.1 Senior management views of advantages and disadvantages of open source software

4.4.1.1 Principal

For the Principal, the main advantage of open source software for the school was its fit with the main philosophy behind the initial setup of the senior high school. With the school vision focusing on building relationships and supporting students, OSS allowed the school's access to software to be unrestricted. Students had access to the same software whether at school or at home irrespective of their family income.

The Principal also discussed the open school philosophy and how OSS gave students equitable access to open source software for learning. The Principal also mentioned that, in the past when she had been Principal of lower socioeconomic status schools, she wished that she had been aware of the availability of open source software then.

The open philosophy of the school also applied to its open Bring Your Own Device (BYOD) policy that encouraged students to bring mobile devices into school to support their learning and connect to the school Wi-Fi network. All students are encouraged to use the school Wi-Fi network for learning irrespective of the device: "It's open access, it's not just open access to some, it's open access to everybody. So that would be the thing that matters most to me." The Principal also briefly mentioned that the use of open source software saves the school a considerable amount of money.

One of the main challenges for the school was identifying open source software that met the specific needs of teachers and students. Because art teachers needed specialist digital imaging software for their students, the GNU Image Manipulation Program (GIMP) was identified as the open source alternative to Photoshop. When the art teachers had problems adapting to the use of the GIMP software, the school employed a specialist in the use of GIMP to work with the three teachers to solve the problems. The mathematics teachers also had similar problems and, with the help of the DP who was the open source software coordinator, those problems were solved: "The problem is not necessarily open source; it's actually computers, not open source." Regarding solving problems with technology and teaching the principal stated: "You have to do that whether you're using proprietary software or open source software; there are always going to be problems."

The principal stated that Libre Office was used throughout the school but that no problems had been encountered because there was little real difference between the skills required to use proprietary office software and those needed to use open source office software. There was little professional development regarding the use of the office software; everyone had experimented and shared the learnt skills.

4.4.1.2 Deputy Principal One

Deputy Principal One stated: "We really want students to be able to access learning wherever they are, whatever they're doing and whatever context they are in. We also think that having access to learning and being able to evaluate things for what they are is really important, and you can do that by looking at a range of possibilities for different jobs." Open source software and free alternatives offer students the opportunities to consider concepts or problems that they are investigating and then look for software to assist in the learning process. Deputy Principal One also mentioned that, because using OSS saved money on software procurement, there was no pressure to use software just because of the purchase cost.

Regarding the challenges of using open source software, Deputy Principal One stated that there was some customisation involved with the wireless network and in managing the intranet domain. The school Google Domain was managed through Google and, although it is not open source, it was provided at no cost through the Ministry of Education Software Agreement (Ministry of Education, 2014).

The first challenge was the way in which staff members used the open source software that was loaded onto their staff Edubuntu-based laptops. A laptop problem was not necessarily the fault of the software; it was sometimes hardware related. Some staff members assumed that the problem was caused by the software because the operating system was different and therefore had something wrong with it. Deputy Principal One also pointed out that teachers were very busy and that there was a learning curve involved in a new operating system. "When you are a teacher, you don't necessarily have a lot of time for that kind of stuff. That can be an immense source of frustration."

The second challenge was that Mac users on the staff tended to be very enthusiastic about their computers, which were generally trouble free and user friendly. "When a problem occurs with open source software, teachers get easily frustrated and put the blame entirely onto the software and share their frustration with their students."

The third challenge was that students became frustrated when learning about software with which they had had no previous experience. Deputy Principal One explained that, because a community of coders developed the open source software for no financial gain, they didn't tend to put the same amount of effort into developing a user-friendly interface that a proprietary software company would. In particular, if users were used to Microsoft menus, they became frustrated with a different interface. There was a wide range in the degree of acceptance of open source software among both teachers and students, ranging from the enthusiasts who were comfortable with open source software to those who became very frustrated with the software and would prefer proprietary software. Deputy Principal One understood that not all teachers and students accepted open source software, but he managed their frustrations in the best way he could by offering support. An example of this was bringing in an expert in GIMP to assist the art teachers who were experiencing difficulties with the interface:

> *There are certain ways of doing things which might not be intuitive to people or they are used to a consistent Microsoft system of menus. So, I can understand their frustration when they come across something that's a little less consistent.*

Related to this was the view that Microsoft Office software or software such as AutoCAD or Photoshop is industry-standard software and that students need training in its use for their careers. Deputy Principal One stated that a learner should be able to quickly pick up the skills needed to use the software and understand the concepts behind it. Once a user learns the basics of a particular type of software, the skills are generic and are transferable between programs. It is more important to understand the applications and the ways in which the specific software can be used. "If you understand the skills that you need for your area of learning, it really doesn't matter whether you know how to use GIMP or Photoshop or whether you are using Inkscape or Illustrator." Deputy Principal One therefore suggested that developing resiliency is important:

> *Are students more disadvantaged by not having the resiliency and an understanding of the concepts that sit behind software or by maybe having not used one bit of software which they can then go and learn about because they're a resilient learner?*

4.4.1.3 Deputy Principal Two

The main advantage that Deputy Principal Two emphasised was that open access software removed a barrier to learning:

> *We've made the decision to look at open source software as a way for our students to be able not just to access ICT support for their learning at school, but also when they're at home or wherever they happen to be or on whatever device that they happen to be able to afford.*

Deputy Principal Two stated that, for each type of proprietary software, the school had looked at whether there is an open source equivalent because skills could be transferred between the use of OSS and proprietary software. "There's also a lovely opportunity for students in terms of transfer of skills, so that you're not only learning by using Mac applications; rather than using Photoshop, you're using GIMP."

Regarding the challenges and problems connected with the use of open source software, Deputy Principal Two stated that operability was not always at a high level; OSS user interfaces were not always well developed, but they had improved over time. An example that Deputy Principal Two gave was Libre Office whose interface improved as OSS developers made refinements. Another example that Deputy Principal Two gave concerned the modelling tool Sketchup which did not initially work on the school network, but the school technician found a solution. When the school encountered problems with some open source software, technical solutions were identified.

Regarding the common perception that open source software would not be used by students when they left school to go into the workplace, Deputy Principal Two stated that the skills were generic and transferable. There appeared to be a mindset that, because you had paid for software, then it must be better.

Deputy Principal Two held the view that the disadvantages of OSS were outweighed by the advantages, especially because open source software is accessible to everyone and there are no cost barriers to installing it on a computer. Students did not have to breach copyright law to install OSS on their computers. Deputy Principal Two stated: “The biggest disadvantage for our students is not having access to software at all because it costs too much, or not having access to software at home because the cost is prohibitive.”

4.4.1.4 Deputy Principal Three

Deputy Principal Three saw the main benefit of OSS for the school as being its fit with the school philosophy that all learning should be student-centred and that learning should be accessible whether from home or school. Because OSS is free for all students and can be installed it on their own computers, student access to software is not limited to when they are at school. “Everyone has a right to an education and we strongly believe that you shouldn’t be disadvantaged, regardless of where you come from and your socioeconomic status. So, if it is accessible for all, that would be one benefit.”

Deputy Principal Three also mentioned that open source software involves a potential cost saving for the school, although he was not sure whether this was the case because the school has access to some free software as part of the Educational Software Agreement with the Ministry of Education. This deputy Principal felt that it important for teachers to “walk the talk” regarding the use of open source software. The Edubuntu operating system was installed on all leased teacher laptops.

Deputy Principal Three stated that a challenge for the school was convincing people that open source software is valuable despite being free. There was a perception that, because the software is free, it is not as good as the purchased version. Because most students did not have open source software at home, there were problems with file incompatibility that could cause frustration.

4.4.1.5 Deputy Principal Four

Deputy Principal Four firstly discussed how choosing OSS was consistent with the school's vision to nurture, inspire and empower. All decisions made across the school must complement the vision and the utilisation of open source software supported the students' learning by removing barriers. Students had access to OSS to support their learning goals.

Deputy Principal Four was surprised at how easy it was to install the software on the school intranet computers, including all desktop and laptop computers. The transition from proprietary software to open source software was relatively trouble free. Deputy Principal Four likened the process to changing to an upgraded version of proprietary software:

> *It was probably the same as moving from something like Windows XP to Windows Vista. The same level of challenge is required there. You may find that the tool that you are looking for is not in the place where you imagine it to be and so you need to develop transferable skills and problem-solving skills.*

Deputy Principal Four also felt that students at the senior high school were not missing out by using open source office software instead of industry-standard proprietary office software. This deputy principal argued that technology is in a constant state of flux and that office software is moving to the cloud. When students leave the school, they would not necessarily use desktop-installed office proprietary software or image editing software such as Photoshop. The school provides GIMP for students for editing images without the large cost involved in acquiring a licence for Photoshop, which involves skills which students might not use in the future. The skills for GIMP are transferable to Photoshop and the short-cut keys are the same.

Deputy Principal Four stated that it was important that the students are given access to a wide range of tools on any device to which they had access. OSS is available for a wide variety of devices ranging from tablets to laptops to enable some students to become producers of software instead of simply being consumers. The equity aspect of open source software, which gave everyone free access to use the tools in their learning in the school, was important.

4.4.2 IT technician's views of advantages and disadvantages of using open source software

The main benefit for the IT technician was that the school was not locked into using any previous vendor and had the freedom to choose software to meet needs. The IT technician gave the example of Photoshop costing $400 per student, whereas GIMP offers similar capabilities for no cost. Software piracy issues were also addressed for students. The main challenge was the initial shock experienced by users who had not previously been exposed to the Edubuntu interface. The IT technician had observed that, after a few weeks, students became familiar with the interface and felt more comfortable about using it.

Regarding the use of Libre Office versus Microsoft Office, the IT technician reported that there had been some problems. The Microsoft Office interface is more polished. The IT technician was aware of some loss in formatting when saving documents between the office suites and recommended that students save documents as PDFs to preserve formatting.

The IT technician also stated that the school deploys Moodle, an open source learning management system that enables teachers to upload their course material and students to download resources. Because Moodle is hosted in the cloud, the only cost is the hosting fee.

The library also uses open source software called Koha. As the IT technician explained, the school had paid open source developers to add Koha software features such as a star rating system for students to use for recommending books. The added features were then shared with the Koha online community.

An array of open source software that supports learning and teaching within the school has been loaded onto school desktop computers. Libre Office has been installed for word processing, spreadsheets and presentations. Each department within the school has specialised software that is specific to both student and teacher needs. For example, the Art Department uses GIMP and Inkscape for photo editing. The IT technician also explained that, because the school uses a lot of cloud-based services, the need for desktop-based software is reduced. Google Apps for Education is used for school email and Google Apps is used for word processing, spreadsheets, forms/surveys and drive storage, thereby reducing technical administration. “We don’t need to worry about anything. No spam, no security issues, no downtime, no archiving, no backups.” The school has a high-speed fibre optic connection to the internet for all school users which the IT technician considers crucial for the smooth operation of devices connected to the school network.

4.4.3 Teachers’ views of advantages and disadvantages of using open source software

4.4.3.1 Teacher One

Teacher One stated that the main advantages of open source software for the school are that it is free and does not involve licence fees and the regularity of updates by the huge developer community. In his teaching practice, this teacher viewed the sole use of open source software as a major disadvantage. In his role as a Technology teacher, he used PLCs (programmable logic controllers) with students. In order to program the logic controllers, the user must connect the controller to a computer that is running Microsoft software. Because the PLC program does not run under WINE (a Microsoft emulator), the teacher had to bring his own Microsoft laptop to the classroom. Another example was 3D modelling software which students can use to design a joint in wood and manufacture furniture in the technology workshop. But Teacher One could find no equivalent in open source software. He saw the sole use of open source software as a barrier to the use of information technology in his teaching practice.

Teacher One did not see the use of Libre Office as a disadvantage for students. But he acknowledged that there could be problems with formatting, which he solves by using Libre Office both at school and at home to facilitate document transfer.

4.4.3.2 Teacher Two

Teacher Two perceived Google Apps for Education as open source software and he chose Google Docs and Google email, forms and calendar in his role as a careers advisor. Google Docs was chosen for its collaborative features which allowed him to give a variety of people access to documents. Technically, Google Docs is a form of SaaS (software as a service) software (Wikipedia, 2021g).

The main advantage of OSS for Teacher Two was that it is free, with only users needing an internet connection to log onto their Google account to access the apps. Teacher Two found the software user friendly and the collaborative features an advantageous for communicating with students:

> *Firstly, it's free; I suppose that is a big element in terms of the open source software packages. But, also, they're readily available anywhere. You don't have to be logged into your computer; you can be logged in pretty much anywhere in order to use it, which is something I have found incredibly useful.*

He saw the main disadvantage as being reliant on an internet connection, because the interface is quite different from the established Microsoft and Apple operating systems and there are limitations with each platform. Teacher Two did not feel that students would be penalised by not having used the de facto Office programs such as Microsoft Office, because the skills are generic between the platforms. Teacher Two believed that what was missing in existing Libre office software was the ability to collaborate and get instant feedback on work.

4.4.3.3 Teacher Three

Teacher Three was the digital technologies teacher, managed achievement standards related to technology and information systems, and previously had experience as an architect and a national examiner in computer-aided design (CAD) overseas. His students work with websites, Hypertext Pre-Processor (PHP), CAD and databases. Teacher Three stated that, from his perspective, there were very few benefits in working with OSS because it did not prepare students well for working in the field of technologies after leaving school.

The main benefit for Teacher Three was that the software was available at no cost to the school and was freely available for students. In terms of disadvantages, this teacher believed that open source software lagged behind proprietary software, particularly in areas such as CAD:

> *The CAD packages available on open source are at least 10 years behind what is commercially available. So already there is a disadvantage and 10 years in computer speak is big time. The other problem that we have is with things crashing and files getting corrupted.*

Teacher Three had also become frustrated with open source software 'crashing' when students use it in Hypertext Markup Language (HTML) for designing websites (e.g. Komposer crashing during use and requiring students to use a HTML editor instead). Teacher Three had not encountered problems using OSS applications such as Hypertext Pre-Processor (PHP) and My Structured Query Language (MySQL) with students because they are used extensively in the business world.

Teacher Three had found Libre office software unstable and that open source project management software was problematic for creating Gantt charts. The software allowed resources to be added, but then crashed, proving frustrating when teaching. Teacher Three firmly believed that, in the field of Information Technology, students at the school should use the software that they will use in their workplaces in the future because alternatives to proprietary software in the IT field are neither advanced nor stable.

4.4.3.4 Teacher Four

Teacher Four, a member of the technology department working with fabrics and graphics, perceived that the main benefits of OSS were that it is free, accessible for all students and available for all common computer platforms such as Microsoft or Apple. Teacher Four felt it important that students have access to software such as Adobe Photoshop or an equivalent in open source software.

Teacher Four had encountered problems with formatting changing when opening files created in Microsoft Office PowerPoint and Word in Libre Office. For example, when sharing resources with teachers from other schools, tables and other formatting did not display correctly when Word files were sent. Teacher Four was comfortable with using the open source equivalent of proprietary software in her classes because the process of creating an image, whether in the GIMP open source software or Adobe Photoshop, is essentially the same:

> *GIMP and programs such as Inkscape aren't dissimilar to Corel Draws and Adobe Photoshop. So really, it's about learning the process rather than being blinded by thinking "Oh, it's got to be Photoshop", for example.*

Teacher Four's philosophy was to give students exposure to open source software as opposed to only using proprietary software, believing that the learning process involved in completing a task is more important than learning specific proprietary software skills.

4.4.3.5 Teacher Five

Teacher Five, a second-year teacher working in visual arts, graphic design and photography, stated that the main benefit of OSS is its availability for everyone, irrespective of background or socioeconomic status. Students could download the software and install it on their own computers or use software installed on school computers. “So, it stops people with limited budgets from being restricted in participating in photography and design.”

The main challenge for Teacher Five had been to learn to use the OSS because she was accustomed to using specific proprietary software. This teacher has immersed herself in open source software, choosing to only use her staff laptop that was loaded with Edubuntu open source software and open source programs available for teacher administration and teaching purposes. This had forced Teacher Five to become familiar with OSS and to struggle at times to familiarise herself with different programs for use in her teaching.

The main problem for Teacher Five was incompatibility with school printers, which also created stress for students when presenting evidence for their NCEA (National Certificate of Educational Achievement) assessments. Although Teacher Five’s students save their work as PDFs, the documents seem to get lost on the network during the printing process. Students still have to pay for printing each file, and the teacher has to document what happened so that students can get a refund.

> *Lots of things seem to get lost in communication between the students trying to print a document and sending it through. We’ll see it leave from the printing window on their computer, see it leave there from their machine. They enter it in and it comes up saying, “So you want to print this?” They say “Yes, print it” and it never comes out.*

Teacher Five, who was trained in using Photoshop, Illustrator and InDesign proprietary software used in Graphic Design, identified that the main difference with OSS as the increased number of time-consuming steps that a designer has to take. Teacher Five also noted that, when students go to university to study graphic design, they are expected to be familiar with proprietary software and could be disadvantaged initially if they are not. Some students purchase their own copy of Photoshop for their BYOD laptop and use it in class to complete their assignments. However, students who cannot afford to purchase proprietary software have the option to use GIMP software and create similar outputs. Because extra time is needed to learn GIMP, students attend extra tutorials offered during school holidays. Teacher Five felt that, when comparing proprietary software with open source software, the difference in photo-editing tools was wider than for the presentation tools:

> *There's a lot more steps in between the different tools to do with photo editing and things on open source than with Photoshop. Students would probably have to work a bit harder initially to get used to the software and do tutorials. I don't think it would hinder them that much as far as the presentation ones are concerned because they are more similar and so I don't think that would be much of a transition.*

4.4.3.6 Teacher Six

Teacher Six, who taught business studies and economics in the school, saw two main benefits of open source software: it is free to all users and updated regularly; and it fits in with the school's philosophy of teaching openness and collaboration. "So the school itself is like the software; it's open, it's collaborative, it's engaging, it's updated."

This teacher Six felt that open source software had an impact on the culture of the school and pedagogical practices. Teaching is in open and collaborative, teaching spaces are creative, and students have open access to the internet.

Teacher Six mentioned students' frustration when trying to open Microsoft Word documents that they had created at home and emailed to school. Documents did not always open and, if they did, fonts and formats frequently did not display correctly. Teacher Six considered that the students' mind set was still to use Microsoft Word for documentation purposes:

> *Most students are still fixed on using Word. Of course, this is a very old argument; we should have been getting rid of Word six or seven years ago. The mindset is still very much about proprietary software and that's why we are not necessarily making the leap to using open source.*

A problem identified with Libre Office was printing over the school network: documents would not print unless they had been converted into a PDF. Also Teacher Six gave an example of being sent some examination papers from the Commerce Association which had some macrons on the fonts which the school network did not recognise. The teacher had to email them to his home, reformat the documents on his Mac and then send them directly to the person who was responsible for printing, thereby completely bypassing the school network. “It seems hard to actually print out Libre Office documents.”

Teacher Six stated that students at the school did not really have an understanding of open source software and that there was a gap between the Ministry of Education’s understanding and the role that technology played in reality in the school system. Students saw technology as being simply an avenue for sourcing information on the internet, whether by telephone or laptop, whereas teachers viewed it much more as a professional learning tool which allowed collaboration and sharing of ideas. Students did not know how to apply OSS to their learning.

4.4.3.7 Teacher Seven

Teacher Seven, a team leader in the English Department, saw the first benefit of OSS for the school as being cost saving. In contrast, in her previous school, a large amount of money was spent on software licences. The case-study school had been using funds wisely for the educational needs of students. The other main benefit was that OSS allowed equal access to software for all students regardless of socioeconomic background. “Good stewardship of finance and I see it as ethical.”

The only problem that Teacher Seven had not experienced with the use of OSS in her classes was the ePortfolio platform, which her students found frustrating compared with working in Google Docs. This teacher was aware that other teachers had worked within the ePortfolio to make it more user friendly and set up links within the platform. Teacher Seven refers her students to other teachers with ePortfolio expertise, but she is aware that she needs to solve some student problems independently.

Although Teacher Seven found adapting to open source software on her school laptop a challenge, she used it for teacher administration and preparation work and found Libre Office software very useable.

Regarding the perception that students should be exposed to Microsoft Office in preparation for the work environment, Teacher Seven stated that Libre Office was very similar. She believed that it is more important to have access to office tools to support learning. Because the tool itself is less important than the process and outcome, Teacher Seven thought it important to challenge the status quo.

4.4.3.8 Teacher Eight

Teacher Eight was an English and Media Studies teacher and was a team leader. The main advantage of OSS (in his context, Google Docs) within the school from Teacher Eight's perspective was its ubiquitous presence. Cloud-based software does not have to be installed on student devices and the software can be accessed and used from school or home. Google Docs are the main tool that Teacher Eight uses in his teaching practice. Google Docs was perceived as OSS.

The main problem that Teacher Eight encountered in using OSS was getting students accustomed to using it. The teacher saw Google Docs as being like any other software and felt that trial-and-error is always needed and that competency is gained by simply using the software. He had experienced some problems in relation to connectivity when using multiple devices, but could not identify any significant difficulties:

> *You have to get used to the process. With Google Docs, for example, it is like any other software. You get a firm grip of the basics through experimentation and through a few instructions and so forth. So, I don't really see that as a problem because you're always going to have that when kids are using technology to create stuff and create work.*

Teacher Eight did not consider it a problem that students used open source software at school instead of proprietary software such as Microsoft Office because it is very similar and students can easily switch between the two.

4.4.3.9 Teacher Nine

The advantages of open source software for Teacher Nine were cost saving for the school, which allowed the school to purchase more computer hardware, and freedom of access to a variety of software, which meant that students learned to use more software. The biggest problem that Teacher Nine had encountered was formatting issues between Microsoft Word and Libre Office Writer. An example recounted was receiving examinations from the Commerce Economics Teachers Association for which some images did not display correctly and the layout had been corrupted. When sending a document to another school, Teacher Nine sends it in PDF format.

Teacher Nine did not perceive that students were disadvantaged by using open source word processor software at school. He thought that, on the contrary, it could be seen as an advantage because students had been exposed to another office tool. Most students tended to have Microsoft Office at home, which Teacher Nine did not see as a disadvantage.

4.4.3.10 Teacher Ten

For Teacher Ten, a visual arts teacher specialising in photography and design, the advantage of OSS was that students could access it and legitimately install on their own devices rather than downloading illegal copies of software. Freedom of access to OSS means that students can run the same software used by the school computers on their BYOD, thus personalising devices because students can bring whatever devices suit their learning style (e.g. tablet, smartphone or laptop).

Teacher Ten felt that commitment to open source software and open learning spaces fitted in with the school philosophy of student-directed learning. He felt that students should be made aware that there are alternatives to proprietary software such as Photoshop, and that OSS puts the ownership of learning on students rather than the school.

Teacher Ten was an enthusiastic user of Google Docs and saw much potential in cloud-based software in schools. Students were able to share documents easily with their teachers and receive feedback on their learning. Teacher Ten felt that Google

Docs had been used more at this school than at other high schools, with students having a wider choice of software to support their learning.

In teaching visual design and photography, Teacher Ten uses software that enables students to enhance photographs and create visual images. After 15 years of experience working with Photoshop and Adobe Illustrator at previous schools, she had built up much teaching experience using the proprietary software in her field and had developed and refined many teaching resources and teaching techniques.

When Teacher Ten arrived at the school, she brought with her on her external hard drive many resources that she had created in her previous teaching jobs. Most of the resources were Photoshop and Word files which would not open using the school open source software. Teacher Ten therefore worked at home to convert the files into PDFs, which she then could not edit or amend:

> *Because the programs here didn't cater for that, I just had to either save them as PDFs, print them off or make changes at home, save them onto a USB and bring them in and print them. So, it was a huge shift at the beginning of the year, but you just have to go with it.*

Teacher Ten rewrote many of the resources and found that quite stressful when starting a new job. Switching to OSS for editing photographic images and image design was a major challenge. The main difference between using proprietary software such as Adobe Photoshop and GIMP open source software was a dramatic increase in the number of steps that the user must perform to complete a set task:

> *You can do a task in three steps on Photoshop, yet it takes you seven or eight steps to do it in GIMP. A lot of students have a short attention span and they get really frustrated if it doesn't work the first time. They can't remember eight steps, but they tend to remember the three steps.*

This created extra work for teachers in preparing written task sheets and video tutorials to explain the process step by step. Teacher Ten found the written task sheets more effective because students find video tutorials complicated.

The other major challenge had been to print documents over the school network. Teacher Ten's students have portfolios that need printing each year, but GIMP and Inkscape gave rise to printing problems that she had not previously experienced with proprietary software. The phenomenon of PDF files going astray on the school network and not ever printing occurs with GIMP, Inkscape and Picasa files, but students nonetheless are still charged for each copy. This causes much stress for both students and teachers, particularly when portfolios are due for assessment. The teachers and the network administrator were trying to sort out this matter at the time. Teacher Ten listed this as the most important problem with open source documents and looks forward to a resolution.

To address the challenges of using GIMP and Inkscape the Deputy Principal invited into the school a specialist in OSS for visual arts. Teachers in Visual Arts and Design spent two days with the specialist in building some resources to solve some of the problems with GIMP and Inkscape software. Although many of the difficulties were not resolved, Teacher Ten was optimistic that eventually they would be resolved and that OSS would continue to be developed to become more intuitive. This teacher would prefer to teach students than to try to sort out technical problems related to software.

Regarding the perception that students should use productivity software similar to what they will use when they leave school for further study or work, Teacher Ten believes that Visual Arts is in a specialist category. Because students enrolling in visual arts in tertiary institutions will use proprietary software such as Photoshop or Illustrator, she was concerned that the school might not be meeting the Visual Arts industry's expectations. Teacher Ten does not think that this applies to office software because proprietary and open source software are very similar:

> *We are a special case and that's why I thought it was good to put my name down to come and see you. I can see the positives and benefits from open source software, but I think in some subjects you actually need to have specific programs that are not going to hinder the students.*

Every Thursday morning, the staff are offered professional development on a voluntary basis to address any problems with the OSS, Teacher Ten found this valuable when she had just arrived in the school and was adapting to new software.

4.4.4 *Focus Group responses about advantages and disadvantages of OSS in education*

4.4.4.1 Year 11 focus group: March Interview (students who had been at their new school for only two months)

Within the focus group, there were differing opinions about the ease of use of open source software; some students found it confusing initially but easier once they had become familiar with the layout and navigation. Students had received help from peers with the software and found it convenient because it was the same on all school computers. One student stated that the layout is similar to Mac software because of the side bar. Students specifically mentioned Google Docs (SaaS software) as being advantageous because of the ease of sharing documents and the ability to collaborate on documents. Students were familiar with Google Docs because it was used in their previous school.

The main disadvantage mentioned was the problem in transferring files between Microsoft Office programs at home and Libre Office software. An example given was that transferring files between Microsoft PowerPoint and Libre Office Impress involved students spending a lot of time restoring the file format. “For instance, if you have a PowerPoint presentation and you go from the software we have here to Microsoft or Mac, it changes everything; the layout is all changed.”

Students mentioned using Google Docs to work around this problem. “If I am typing something in class, I will just put it on Google Drive instead of saving it on my school account so I can share it with myself at home.” Compatibility of files between open source office software and Microsoft office software was the main disadvantage discussed, while the group saw the capacity to collaborate and share work to be the main advantage of Google Docs.

4.4.4.2. October Interview Year 11 Focus Group (same students as March interview)

Students reported that they had become used to the OSS operating system over time and that they were familiar with the Edubuntu operating system. Students found that Libre Office, particularly the Writer software, was very similar to Microsoft Word. “They have kept the interface similar enough, and so we know how to get around it reasonably well. I wouldn't say that it is as great as Microsoft Office but it is certainly really good."

A male student reported that he had installed some OSS onto his laptop because he had found GIMP useful for editing images. Although he found it confusing at first but, as he got used to the navigation, he was able to create textures for some programming. Another male student noted that OSS had opened students' minds to alternative software that was available for everyone at no cost. "It's shown a different way; there is not just Microsoft out there anymore. There is all this other stuff and there is great potential behind it: different learning and accessing resources that we couldn't previously without paying."

When discussing the main advantages of open source software, students began by commenting about how they liked that Google Docs was not only available via the school network, but was also in the cloud (Google Drive). Students could improve their assessments if they can work on documents from home. The reasons given by the students for using Google Docs over Libre Office were:

- *Easier to use.*
- *Quicker and more organised.*
- *Saved automatically.*
- *Documents can be edited live.*
- *Teachers can give feedback on students' work.*
- *Teacher comments are exactly where students want them instead of at the bottom of a page.*
- *Documents can be easily shared.*
- *Multiple editors can work at the same time.*
- *It feels like the right thing when you are on it.*
- *You don't have to put it up from your school files; it is already there when you create the file.*
- *The students can access Google Doc from multiple devices (e.g., laptop/tablet or mobile phone).*
- *Students are not restricted to a fixed location when accessing Google Doc.*
- *Google Doc is accessible from different devices: (tablet, four students) (mobile phone, five students) (laptop, nine students).*

Students expressed their frustration about a lack of communication from the school about the OSS and how it could be used in their school work:

> *The biggest thing about open source is that we have a whole school full of open source stuff. It would be useful to be told about it and to have a little bit*

> *explained to us at the beginning of the year. We now know we have these resources that we can use which we didn't know at the beginning of the year.*
>
> *We go to the computers and there is a whole lot of different software. We say, "What's this? "While trying to figure out everything. It took me 20 minutes to find the equivalent of Microsoft Word.*

4.4.4.3. Year 12 focus group October interview

A male student commented that he would only use Libre Office for school work and stated that every computer in the school was loaded with open source software, which was free. Another male student reported that he didn't have any problems learning how to use OSS, whereas female students felt that its layout was confusing: "Navigating the computer is quite hard because not everything is there to find."

The advantage of OSS perceived by the group was that the school didn't have to spend thousands of dollars on software and could put the money towards other things. "There are more computers and more money can go to other curricular areas of the school. The art room is quite good. Every department is quite nice."

A male student commented that that all school computers having the same software was an advantage. Desktop computers were scattered throughout open learning spaces in small pods so that, if students became familiar with one computer, they would find that all other computers in the school were the same. A male student stated that, when students had their own laptops', they could install the same open source software for no cost.

Students mentioned file incompatibility between Libre Office and Microsoft Office that affected ability to email a document to home addresses for further editing, a problem mentioned particularly by female students. Male students replied that there are ways around the file incompatibility, ranging from converting the files to downloading Libre Office and installing it at home. Students mentioned the inconvenience of having to remember different layouts between proprietary and open office software.

Male students then discussed differences between Inkscape and GIMP compared to Photoshop. GIMP is relatively complicated but students had used internet tutorials for assistance. Comments about GIMP from male students included: "Open source software is usually really complicated. Because they are selling it for free, they don't have the money to make it super easy to navigate. It is really confusing but you kind of get used to it.”

Male students also complained that school computers were very slow, but they did not know whether it was because of the software and how much was loaded onto the computers. Students agreed that a major advantage of OSS being loaded onto all school computers was that everyone was using the same software:

> *Everyone knows it. It’s in your brain. Everyone uses the computer at this school. Everyone knows. Even if you haven’t used it before, it is guaranteed that someone in the school has used it. So, it is really easy to get tutorials from people.*

Overall, students were positive about OSS and noted that the computers did not crash. Because students had a login to the school computers, the desktop was always the same for all computers and saved files were present on the computer.

Students discussed the importance of Google Docs as key software for school use. They liked the facility for multiple editors to work on the same document and that changes are visible in real time.

4.4.4.4 Year 13 focus group April interview

The group saw that the main advantage of OSS is that it is free to download and use and therefore available to everyone in the community. Students thought that the software was helpful in the school: the source code was visible and coders were able to improve the software if needed. Students had the option to install open source software at home if they needed to. Because OSS was available at no cost, it freed up money in the school budget to spend on the students, which Year 11 and 12 groups also mentioned.

Year 13 students also found that documents that were created in Microsoft Office lost some formatting when opened in Libre Office:

> *Often it would screw up the formatting. We would be writing a report for Biology and have it all formatted so that it would look really nice. Then we would put it into Libre Office and it would mess everything up. (e.g. bullet points would be un-numbered).*

Students commented that Libre Office was quite dated and similar to an older version of Microsoft Office. Students had problems with the fonts in Libre Office and with printing documents on the school network. When documents did not print as they were displayed on the computer, extra time was needed to fix this. Not all students were critical of Libre Office, with one student stating that, once he got to grips with the features and layout, he found Libre Office quite intuitive and easy for learning new features.

Students who studied photography stated that GIMP was not user friendly and was complicated to use. While acknowledging that GIMP was free, they felt that programs like Photoshop were more user friendly. Students found that, although the Edubuntu desktop was relatively easy to use and navigate, individual programs could be difficult to use. Overall students preferred to use proprietary software. When the researcher asked the 10 focus-group students whether they brought their own laptops to school, most replied that they did:

> *I would say the main point of the open source software is the fact that it is free. Most programs that you pay for are better, I would probably say. With all the open source software that I have used, I have preferred the paid version. I prefer Microsoft Word to Libre Office Word. I find it a bit easier to use and I hardly ever use the school computers because I use my own laptop.*

Students also complained about the school internet connection: "Most of the time it is slow. In tutorials and on Impact Project days, it will keep randomly disconnecting and going slow and you can't learn anything."

4.4.5 Web survey results: Advantages and disadvantages of open source software in educational context

In the web survey, the Year 11, 12 and 13 students were asked what they liked about using open source software at school. The frequencies of different responses are graphed in Figure 4.18 to illustrate that ease of use was the top attribute cited, which can be contrasted with responses during focus-group interviews. This could be related to the use of Google Docs (perceived as OSS) which was widespread among both teachers and students. Other attributes including free availability, home/school use, learning support and availability are all related to ease of access for everyone regardless of socioeconomic status. This was also reflected in teachers' responses about wanting software to be available to all students.

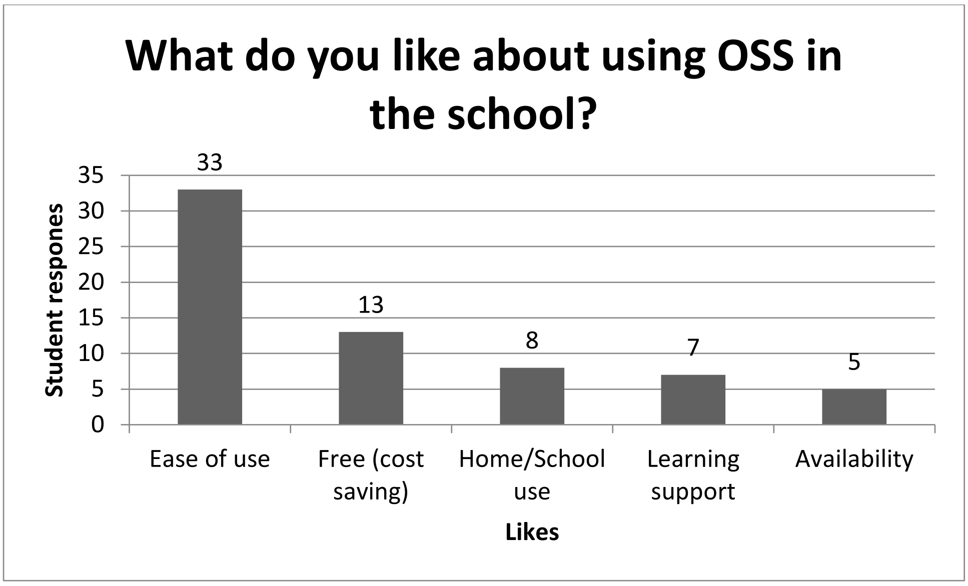

Figure 4.18: What students like about using open source software

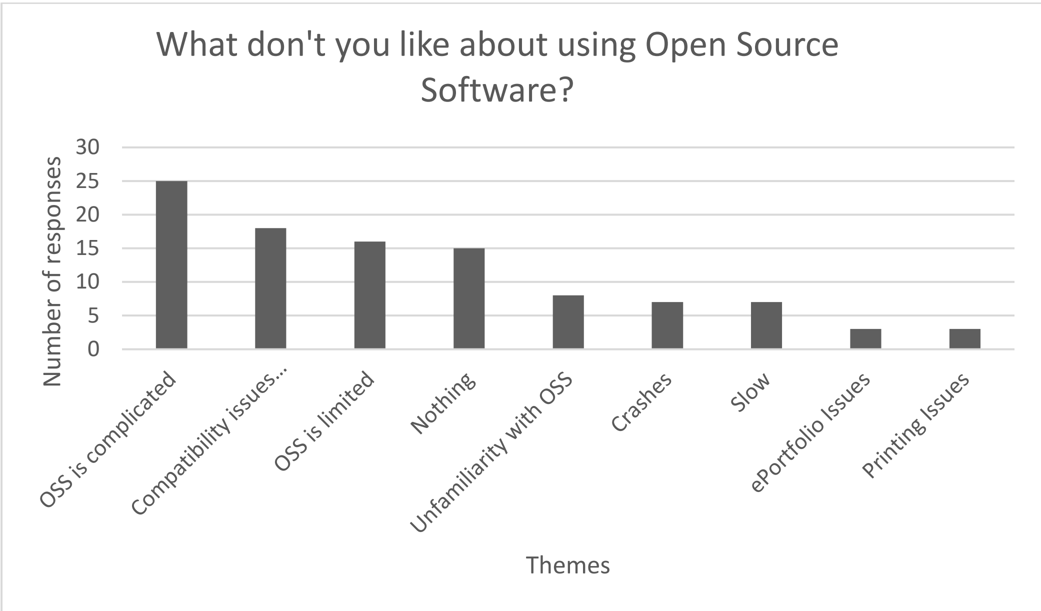

Figure 4.19: What students don't like about open source software

Figure 4.19 shows the frequencies of various responses when students were asked about what they didn't like about OSS. 25 students thought that OSS was complicated to use in the school, which is consistent with focus-group responses, particularly with regards to graphics and image software. Compatibility of office files was also a major problem for students, particularly when emailing files from school to home for further editing. This was also raised in the focus groups and was seen as a barrier to completing school work by some students.

Some teachers and students identified that OSS did not meet industry standards for completing tasks. This was mentioned also in teacher interviews and student focus groups. Printing problems were also mentioned by both teachers and students in their interviews.

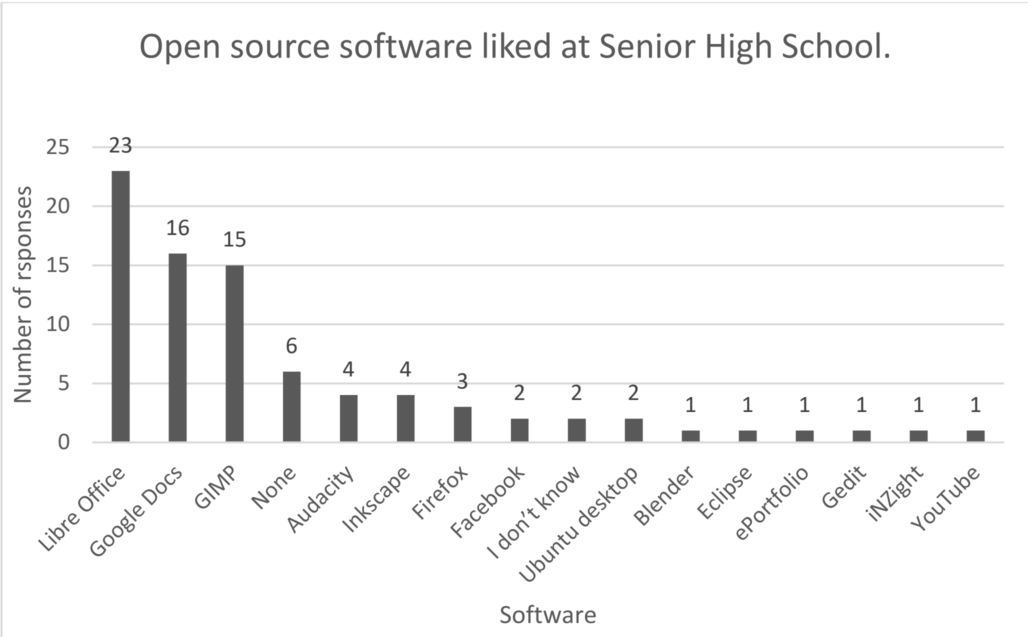

Figure 4.20: Number of students liking different open source software

Students were asked to identify their preferred OSS and the frequencies of responses are provided in Figure 4.20. Students chose Libre Office most frequently and this includes the word processor, spreadsheet and presentation software (see Figure 4.20). Comments about Libre Office included:

- *I just like it and find it easy.*
- *It's easy to use.*
- *Because it is similar to Microsoft Office which I use at home.*
- *It's okay as it is a lot like Microsoft Office.*
- *Because I do most of my school work on it.*
- *Because I use it the most.*
- *Libre Office is helpful because of its compatibility.*
- *I like Libre Office. It's just as easy as earlier versions of Microsoft Word and can do the same things.*
- *I like Libre Writer because it is similar to Word.*
- *I like Libre Impress because you can make good PowerPoints.*

Although Google Docs (SaaS software) is not open source software, it was perceived as such by many students (see Figure 4.20). Students commented on the value and use of Google Docs in the school:

- *I like it because it saves work instantly and it is easy to communicate with teachers on it.*
- *Google Docs is really useful.*
- *Google Docs is simple to use.*
- *Google Docs can share and link.*
- *I like Google Docs because it can be accessed by all of the teachers also.*
- *I use Google Docs a lot, it is really helpful.*

GIMP software, advanced OSS image editing software (see Figure 4.20) was also popular with students as an open source alternative to Photoshop proprietary software and it was used by the Graphics Department for editing images:

- *GIMP: You can actually rotate stuff on it!*
- *It is easy to use.*
- *Because it is beneficial for my photography work and fairly easy to use.*
- *It's easier for me to use than Photoshop.*
- *Free, basic Photoshop alternative.*
- *I only really know how to use the image editing programs such as GIMP and Inkscape and I like using them.*
- *You can do a lot of different things for free on GIMP.*
- *I used GIMP for my impact project last year. It was really handy.*

Inkscape and Audacity are software for graphics and music/sound editing (see Figure 4.20). Comments from the students included:

- *It's really useful. (Inkscape)*
- *I can do a layout for a photography board without needing my board there. (Inkscape)*
- *Audacity, which I also use at home to record audio as it allows me to export as an mp3.*
- *I can create my own music and develop it more into something I might be interested in. (Audacity)*

Six students indicated that they chose not to use the OSS at all for different reasons. "I prefer not to use this software and they are difficult to use."

4.5 Pedagogy Used in Classrooms by Teachers in Relation to Open Source Software

Wheeler (2013, para. 3) defines pedagogy as:

> *Leading people to a place where they can learn for themselves. It was about creating environments and situations where people can draw out from within themselves, and hone the abilities they already have, to create their own knowledge, interpret the world in their own unique ways, and ultimately realise their full potential as human beings.*

The role of open source software in supporting the pedagogy used by teachers is the focus of Section 4.5. Does open source software support students to learn for themselves?

4.5.1 Senior management: Pedagogy used in classrooms by teachers in relation to OSS

4.5.1.1 Principal

The Principal stated that, in setting up the Senior High School, teachers wanted to remove as many barriers as possible to student learning. This included removing prerequisites for subject choice, extending the school periods to 120 minutes, building open learning spaces, giving access to open educational resources, providing freedom for students to bring their own mobile devices into class, and giving students the opportunity to use open source software. OSS was selected because it was available for everyone at no cost and therefore enabled a wide range to be made available for every subject within the school. The choice of open source software fits the ‘open’ philosophy which permeates the school.

The Principal gave an example of Impact Projects (Albany Senior High School, n.d.-d) which are scheduled for every Wednesday. These projects are “highly structured, project-based learning experiences that you develop in teams or individually with guidance from your mentors at school and in consultation with experts in the community” (Albany Senior High School, n.d.-f, para. 2). Students identify their own proposals and, in consultation with a mentor, work through four key stages: proposal, progressing the plan, presentation and evaluation (Albany Senior High

School, n.d.-e). Open source software, specifically Mahara ePortfolio, is used to document the learning process/reflections throughout the Impact Project. The Principal stated:

> *We have dedicated a whole Wednesday to it, when students are able to bring themselves to it and not be limited by their teachers or the curriculum or the assessments. So there are no limitations. That's what 21st Century education is to me and that is where Impact Projects are.*

The Principal believed fully in open education and that students should be allowed to take their mobile devices into the classrooms for learning purposes:

> *It's a bizarre thing for a school to say the kids can't have cell phones or whatever it is in the classrooms. Here they are sitting with this device that they can connect with the world on just like that. Why wouldn't you harness that, what would stop you doing that – is it the limitations of the teachers? What is it that stops you as a learning institution opening up things up for everyone? What stops you?*

The Principal discussed the open teaching spaces throughout the school, how the use of OSS fitted well into the concept, and how collaborative practice and an awareness of other teachers are encouraged. According to the Principal, younger teachers at the school perceived the open teaching spaces as normal:

> *Open classrooms have de-privatised your practice completely and that's why the open source has fitted so well. The teachers' collaboration is extraordinary and I hugely admire them because it is a completely different way of teaching.*

The Principal also mentioned that, because the school operates on 100-minute periods, teachers need to be very organised with their lessons. They teach alongside their colleagues in the shared teaching space where they support each other. Ideas and pedagogies were shared between different subject areas:

> *You're beside a maths teacher or a PE teacher or whatever; you're right beside them and I think it's hugely interesting. Then they come back into their workroom and ask each other: "What were you doing? What was that strategy?" So they're improving their game all the time.*

The Principal was excited that the younger teachers shared the digital world that students inhabit. Teachers have Facebook pages for students and operate them outside school hours. The teachers and students interact with each other online in a match of learning styles:

I'm excited by watching the way these young teachers interact with the kids. They set up Facebook pages. That's the way they interact with each other, they're on Facebook all night and they're all on Twitter. It is a different way of being and it's the world the students are in. These young teachers are in that world. (Principal)

4.5.1.2 Deputy Principal One

Deputy Principal One stated that open source software gives students access to software that can support their learning in any context without being limited to one particular type of software. "We really want students to be able to access learning wherever they are, whatever they are doing and whatever context they are in. So for students open source software and free alternatives offer them the ability to do that."

This Deputy Principal also felt that open source software allowed students to explore the concepts behind what they were doing. The large variety of OSS meant that students could locate and use software that supported their learning with no financial or permission barriers. It was student choice of software to support their learning or problem solving that was important:

We want the students to have access to knowledge that sits behind the learning. I'm not saying you can't do that with a different type of software but it gives us a chance to focus our teaching as much as we can and as much as it is helpful for students on concepts and ideas and ways of doing things rather than saying, "Learn this single process in this particular piece of software and that's what we're teaching you to do.

Access to a range of open source software meant that students could focus on the inquiry process and locate and use software that could help them solve the problem:

[The student thinks:] Here's the problem, I need to spend time figuring out what that is. Now I need to look at the possible tools I can use to help me with that. By having a set up where students can choose from a range of things, we're hopefully helping them to learn that whole process of analysing a situation, which is a really important skill. (Deputy Principal One)

Deputy Principal One also mentioned the importance of engagement with technology in supporting students' thinking process:

Part of the idea is that students will engage with technology really well in a way that advantages them. If they make a decision around a collaborative tool as a way of solving a problem, then that's awesome to me because it is even more 21st Century.

Access to a range of open source software, according to Deputy Principal One, meant that the school community had the flexibility to use appropriate software whereas, when the school purchased proprietary software, there was an obligation to use it no matter what. To justify the money spent, it must be seen to be used. This could be at the expense of a new innovative technology which might be superior but could not be used because the school had invested in proprietary software.

Deputy Principal One explained that, through its broadband connection, the school also had access to a wide range of cloud-based technology (SaaS). The school had signed up for a Google Education account that made available a variety of Google applications for teachers and students. Google Gmail was used throughout the school as was Google Docs, which includes Google Drive for storage, Docs, Sheets, Forms and Slides. It was clear from both teacher interviews and student focus groups that Google Apps was used widely throughout the school by both students and teachers.

The open source ePortfolio platform Mahara was used throughout the school for Impact Project planning, recording and sharing of learning achievements. Open source Moodle was used as a learning management system for supporting online learning in the school. Deputy Principal One acknowledged that the Moodle-based Intranet was not as widely used as the Mahara ePortfolio system.

Each curriculum area made specific OSS available to support student learning. Deputy Principal One noted that there was a wide variation in software used within the school, with the important criterion being that it must support student learning within the curriculum area. Flexibility was important and student-centred learning were paramount. If OSS did not meet student needs, then proprietary software could be substituted. An example cited was the use of Final Cut for the suite of Macs in Media Studies because the open source video editors were found to be unsuitable for student use and did not support their learning. Sibelius was also used by the music department on the Mac computers to support student music composition because there was no equivalent open source software available:

> *There is real variability depending on what the students want to use. That creates a bit of extra learning for staff finding out what students decide to use and then helping them do their learning within that. We still use commercial software in some instances. For example, media studies are really keen on Final Cut on the Macs and we looked at Light Wave.* (Deputy Principal One)

The BYOD scheme encourages students to bring their own laptops and mobile devices to classes. If the students have proprietary software that helps with their learning, then that is used. There was flexibility throughout the school in terms of software used. However, Deputy Principal One noted that this could create the need for extra learning for the teachers in order to support all the students:

> *In digital design, students use Inkscape and they use GIMP in the design and photography classes, but then there will be other students with their own laptops who use Photoshop export to PDF and use the Ubuntu network machine to do their printing. So, there is real variability just depending on what the students want to use.*

Deputy Principal One also highlighted that the school's flexibility regarding software and the Impact Project choice (Albany Senior High School, n.d.-d) has allowed some students to develop their own software through software programming. Quite a few students had become proficient at programming in Java largely because of Minecraft. Students had contributed to open source projects and had created some mobile telephone apps as part of their study. Deputy Principal One gave the example of a student who wrote a musical theory application for a Microsoft mobile telephone in the C Sharp programming language. The student wrote the application from scratch without having programming skills. The musical theory game was very popular with students as explained by Deputy Principal One:

> *That piece of software is freaking awesome. That's a task that traditionally a music teacher would do at the beginning of a lesson. It would take them 15 minutes to do the same thing that you can do on that game in two or three minutes. The students can compare their scores with each other and they can have battles.*

Deputy Principal One concluded that writing mobile apps was an area that would develop in the school in the future because students had the freedom to program mobile apps.

4.5.1.3 Deputy Principal Two

Deputy Principal Two's comments focussed on the collaborative aspect of open source software (e.g. cloud-based SaaS software Google Docs):

> *One of those things that we talk about in terms of pedagogy is being able to discuss your work rather than working in isolation. The kinds of dispositions with which we need to be supporting our students include great*

> *communication skills, talking about and checking your understanding and testing it against each other, and the collaborative nature or part of learning.*

Deputy Principal Two gave the example of a class using WikiEducator for collaboration on a shared document. On the school WikiEducator site, many resources are shared to help both students and teachers with their learning. Resources uploaded to WikiEducator are classified as Open Educational Resources (OER) which are shared with the worldwide learning community:

> *WikiEducator has the same kind of pedagogy behind it. It's about collaboration, collective intelligence, and students being able to pull in information into WikiEducator for particular classes to make videos about how to learn, what to do and upload them.*

Deputy Principal Two acknowledged that the use of open source software such as WikiEducator and Mahara ePortfolio was not consistent throughout the school because of variation in teacher confidence with using the software.

ePortfolios were used by students as repositories for evidence of learning and as a reflection tool for learning which was shared with the teachers for feedback. Teachers uploaded templates into the ePortfolio platform which the students used as planners for learning and for reflection. Student learning was also showcased through the ePortfolio. Also, Deputy Principal Two explained that teachers use ePortfolio in their professional practice as a reflective/evidence tool for teacher certification purposes and for sharing information among themselves:

> *We do professional inquiry for our learning journey and, as part of that framework, we are required to test our theories and get other people to give theories to us to consider why something might be happening in the classroom. We can do that via the ePortfolio.*

Students also had access to a wide range of software on school computers and could support their learning while trying out different software. Deputy Principal Two stated: "They have some agency around the software so they can choose to support their learning in ways that perhaps we have not even considered and thought of before." This Deputy Principal also recalled that, as part of the Impact Projects, students had been able to locate open source software to support their learning and then had this software installed on the school network for other students. There was also a timeliness aspect because the delay in locating and installing the software was minimal because it was without cost.

Deputy Principal Two discussed the importance of personalising learning opportunities through mobile telephone applications for both Android and Apple iOS software, because many apps were available at no cost through app stores. This was especially useful for supporting students with learning difficulties. While Apple iOS software was proprietary, coders had the opportunity to create apps for Apple iOS devices. The Android operating system was based on OSS and coders also had the opportunity to create apps for it. Many students brought their portable devices to classes to support their learning.

Students were writing code for computer software, thus making them knowledge producers rather than simply knowledge consumers:

> *Our students are now making a contribution to programming and to app development and to writing code and that kind of thing. So, they're not just consumers. Students are beginning to do this largely because of the Impact Projects that we're beginning to contribute to.* (Deputy Principal Two)

According to Deputy Principal Two, the school was becoming more confident about the use of OSS and was developing a skill base in curriculum areas where it could support learning. An example of this in visual arts was an outside expert being invited to upskill staff on the use of GIMP.

In a school using open source software, teachers had to problem solve when things did not go well and collect resources to help them in the future (Deputy Principal Two). OSS aligned well with the values of the school's delivery of an open educational pedagogy with open educational software, open educational resources and teachers being open in their pedagogy. Students were also given freedoms such as BYOD and an open choice of topic for their Impact Projects.

4.5.1.4 Deputy Principal Three

Deputy Principal Three stated that the most important aspect of pedagogy was putting teaching and learning first and allowing technology to be complementary to that. "I think the best app is always going to be a good teacher." Therefore, teachers focused on teaching and learning and then selected technology to integrate into the learning process. OSS allowed risk-free trial of new technology rather than paying for proprietary software that might not fully support learning and that teachers might feel obliged to use:

> *It's how we teach; we look at tools that will aid the learner and the learning as opposed to saying, "we've got this new-fangled tool and we want to use it and so let's work out a way to use it". I've been in another school where they paid considerable money for a piece of software and so they really wanted everyone to use it more. We found out that it actually wasn't fit for purpose but, because we'd spent thousands and thousands on it…*

This Deputy Principal noted that, although he had not had any face-to-face classes in the current year, students shared Google Docs with him and asked for feedback. Also, the social networking tool Twitter was used by teachers with students. By using hash tags and follows between students and the teacher, students were able to diarise and make notes in real time. Teachers could check students' notes, students could ask questions in real time, and teachers could also message students and ask questions related to the topic of study:

> *So they use Twitter to diarise things and note stuff. That's been fantastic. One of the drawbacks of what we were doing previously is the kids could document in real time but the teacher couldn't check to see if they had.*

Deputy Principal Three also acknowledged that Facebook was the principal communication tool. School resources and information for students were available on the school Facebook pages and in closed class groups.

4.5.1.5 Deputy Principal Four

Deputy Principal Four stated that OSS gave all students access to software that they could install on their own devices with no restrictions at school or at home. Free access to open source software also gave students a wide variety of choices which meant that they had access to software that met their subject needs. For Deputy Principal Four, OSS was about freedom and giving students choices.

Regarding Impact Project days, this Deputy Principal considered them as good examples of open source software being used to support student learning. He recollected that, in his experience, GIMP was widely used for graphics manipulation and Libre Office was used to edit documents and spreadsheets. Students were also supported in developing smart telephone apps using MITS app inventor. If students wished to develop a computer game, then OSS was located for the student to use:

> *The crucial thing is students getting access to a wider range of tools on any device that they have access to. That is vital. The other in terms of learning is the importance of sharing, collaborating, getting feedback. The open file*

> *format, where you can share something around half a dozen different people, gets them to open a document, make a comment and then send it back to you, which is crucial in terms of learning as well. To learn how a tool works enables that transition from being a consumer of digital tools to someone who is potentially a producer of one or someone who is able to make a contribution to it.*

In addition to access to a wide range of open source software, the school made a commitment to provide students with open access to information through OER. The school had developed a Creative Commons copyright policy and uploaded curriculum documents to WikiEducator. Both teachers and students had access to the content on WikiEducator and were encouraged to edit WikiEducator school pages and share information.

4.5.2 IT technician: Pedagogy used in classrooms by teachers in relation to OSS

From the IT technician's point of view, OSS's main benefit was collaboration (i.e., collaborating with other online communities). If the IT technician had any problems, he posted to an OSS forum and waited for somebody to suggest a solution:

> *You just collaborate with other communities. Education is collaboration – sharing knowledge and all that, so it actually fits into the education system. Say I've got issues with open source software. If I want a fix, I just ask somebody else on the forum and they reply back to me. It's kind of helping each other.*

Using open source software meant that the IT technician had customise it to suit the school's needs and improve students' experience with the software. An example of this was the school paying a software developer to customise the Koha library management software to meet the school's needs. Improvements were then shared with the wider Koha user community. The IT technician specifically mentioned the use of the OSS Moodle learning management system to allow teachers to upload course material and students to download content out of school hours.

4.5.3 Teachers: Pedagogy used in classrooms by teachers in relation to OSS

4.5.3.1 Teacher One

Teacher One was a technology teacher who previously had worked as an electronics engineer and programmer. This teacher was experienced in the use of technology and managed workshop classes in which students engaged in design technology or product design and made products to support their learning. Teacher One had a crucial role during the Impact Project days as an advisor to students when completing their Impact Projects. Students in Teacher One's classes were involved in hands-on constructive learning which involved programming electronic devices and physically constructing projects in the workshop area.

The use of Pickaxe (a small chip that connects to a computer) was explained by Teacher One. Students wrote a code to control the chip which was then used to control a robot or device. For example, a robot could detect that it had reached a wall and could then be instructed to turn around and go the other way. Pickaxe was only programmable using Microsoft software and so there were problems in using an emulator through Ubuntu. "That programming part can't be done under Ubuntu and it's actually stopping us from doing that particular thing because I tried to get it up and running two years ago and it ended up in the too-hard basket to be honest." Teacher One brought in his Microsoft laptop if it was needed during his teaching to allow students to program devices as part of their learning. Teacher One explained that he used software to model wood joints in furniture so that they could be created and tested, but that software only runs under Microsoft.

Teacher One explained the process whereby new open source software could be sourced from repositories and installed on the school computers should a need arise.

> *If a student comes to me and says that "I need to do this thing" and I say that "there's an actually a nice piece of software now to do that", they can jump on and find it in the repository. If the school hasn't got it, I can go and see the IT man and say that "we need this bit of software for these particular students" and there's no cost.*

This teacher noted that, although 3D printers were now part of secondary school workshops, all 3D printers except one run on Microsoft software only. The school had purchased a Microsoft-based computer to run the software for the 3D printer.

Teacher One was very technically literate and found solutions to most problems associated with reliance on open source software. The students were not aware of the problems because they were solved by the teacher in most cases. However, Teacher One suggested that using a Microsoft network for his workshop would improve his teaching and make it easier. Microsoft-based programs, which were used to control most equipment and PLCs in the Technology area of the curriculum, would add flexibility. Most of the engineering world at present still relies on Microsoft-based software.

Teacher One used the ePortfolio software (Mahara) for students to file share, submit completed work to the teacher, and accessed Mahara on BYOD devices:

> *There's a folder for homework; if it is not there, it is getting marked. Any resources go in there. The students can access that folder. They can put their files in, I can put files in, they can take files out, they can put homework there.*

This teacher commented that the BYOD system worked very well because, although the school network was Linux based, there were no problems with Microsoft devices connecting to the network. At the senior high school, there were no barriers to connecting devices which were used as an integral part of learning:

> *The ideal is to make it as easy and stress free as possible to bring a device. If it became a hurdle, kids being kids would just not be bothered. You will see some students on laptops, some on phones, some on pads, doing whatever work that's needed to be done. I think that we can do it here and there is no stigma about bringing a device.*

4.5.3.2 Teacher Two

Teacher Two was a specialist career teacher who used the Google Docs suite extensively for communicating and working with students. Google Docs, Forms and Calendar were used for student pastoral care. The community aspect of Google was important because everyone in the school used the cloud-based software Google Apps for Education to give teachers instant feedback so that they could give students advice on career pathways and progress. Google Apps for Education was an integral part of his teaching practice.

As Teacher Two explained, with Google Apps for Education suite, student work received feedback/comments out of school hours so that students could then prepare their work for the next day:

> *It allows students to work pretty much anywhere and teachers to give feedback outside class as well, which I think is really valuable for students. I've known teachers to be providing feedback at 8 or 9 o'clock at night and then students who are up usually a little bit later can be working on that straight away rather than waiting until the next day to get that feedback. So, I think, in terms of the teaching pedagogy, we have here certainly aligns brilliantly with what we're wanting to achieve.*

Regarding pedagogy, Teacher Two thought that the biggest advantage of Google Docs was instant feedback for students. Student–to–student and student–to–teacher collaborations were another advantage, as was access from anywhere on any internet-connected device. "Students can access it from anywhere, they don't need any special software, they can bring their own device and it will run on their own device. That is a pretty big plus as well."

Teacher Two also mentioned that the school had been involved in a trial with Careers New Zealand using the OSS ePortfolio platform Mahara. Because the site needed a lot of front-end work for it to be successful, the school was working with Careers New Zealand on how best to implement that. While students were at school, they developed their ePortfolio and CV. When they left school, the ePortfolio was then registered with Careers New Zealand and remained there for life. "The benefit of the ePortfolio is that students will be able to take it with them to their tertiary institutions. Basically, you're just continually adding to it and it just builds up your profile."

4.5.3.3 Teacher Three

Teacher Three, the digital technologies teacher, made extensive use of OSS in his teaching. The difficulties that this teacher had with OSS have been discussed in the Section 4.4; he considered OSS to be dated and to limit his teaching and that industry-standard proprietary software should be used for teaching digital technologies.

Pedagogically, it made no difference whether Teacher Three was using OSS or proprietary software. Regarding resources prepared for his students, he used his

Microsoft home computer to prepare resources in Word and then converted the Word document into a PDF to bring to school for his students. For presentations, Teacher Three used Google Slides because he could work on the presentation from school or home. So far as software was concerned, he saw advantages in cloud-based software such as Google Apps (e.g. students could access software at both school and home because files are always saved in the cloud).

Teacher Three uses the flipped classroom concept in class, with students viewing the concepts on which they will work the next day during the previous evening at home. That is, students have a preview of the new concept before the class. The teacher creates videos and loads them onto an internet website to make them available for students to view from home. During class, student-centred activities are based on the previously-learned concepts. The flipped classroom approach was defined by Szparagowsi (2014, p. 0) as "a form of education in which students learn new content during out-of-class-time instead of the traditional review exercises that are normally given, which opens up class time for activities, problem solving, and other forms of instruction." Teacher Three explained:

> *If I'm going to cover something tomorrow, say producing forms in html and the different aspects of that, I can produce a 15-minute video, put that on the internet and then tell the students they've got to view the video before they come to the next class. Then there would be certain questions that they would have to answer to make sure they've done it. Then when they come to class, they can get stuck in, do the work and I can go around and just help and support them, rather than spend time actually covering that material.*

Regarding communicating with students, when Teacher Three had tried Facebook on previous occasions, it worked very well regarding instant feedback from students, but he was uncomfortable with friend requests from students and stopped using Facebook. Teacher Three was interested in reusing the Facebook page concept in the future because it had worked so well with students.

This teacher was aware of the presence of the Moodle Learning Management System in the school but did not use it because students were used to a digital routine for their learning that excluded Moodle.

Teacher Three was currently using Edmodo, which worked very well as a learning management system to give students access to resources and enable them to submit completed assignments. Edmodo was free for teachers to use through a basic account, was proprietary software, and has an app that teachers and students can install on their telephone or tablet. The teacher mentioned that, at night, his telephone beeped when students had submitted an assignment. Edmodo allowed this teacher's students to engage in hands-on applied learning on the computers during his lessons:

> *What I do is I put the subject up. So, you've got level one digital and then under that you can make small groups. I make a small group for every achievement standard. On the main page, I put the week's announcement so I basically put the learning intentions and outcomes for the week on the main page so that, when they click on digital level one, it comes up and will direct them. This week as we are doing achievement standard 2.2, they will go to that small group and then there's further information specific to that.*

The main advantage was that students and their caregivers could access the resources at home.

4.5.3.4 Teacher Four

Teacher Four, a teacher in the technology department, worked with graphics applications and used Google Docs to record practical tasks carried out in class. Google Docs was used for report writing and general teacher administration tasks because it could be accessed in multiple locations and shared easily with students and teachers in the school:

> *In terms of report writing and things, we'll use a Google Doc which can be shared with me and I can access it from home. I could access it if I was sitting on the train, students can access it at home and we can still be communicating when it's suitable.*

Facebook was used by Teacher Four to communicate and give students access to resources. "I have a closed Facebook group for each of my class groups and we can communicate through the Facebook group page, mainly for looking at resources, reminders about what is coming up, or information that is shared." The reason why Teacher Four used Facebook was that students used it. Because students liked Facebook more than email because it was synchronous, there was a higher hit rate through Facebook for messages than email. Teacher Four gave some examples of how Facebook was used in her teaching practice:

> *Sometimes we've used it to upload tasks. For example, when looking at elements of design, students went around the school and photographed*

> *examples of repetition, shape and structure and then they uploaded those onto the Facebook group and other students commented. So, it can be part of a learning tool as well.*

ePortfolios (Mahara) were used by Teacher Four for both student use and personal reflections on her teaching practice because she was a beginning teacher. She used ePortfolio with a digital technology class for students to record their learning intentions and reflections. Teacher Four did not find the Mahara software interface intuitive but sharing templates with students improved the student experience:

> *I think that, once you have got to grips with it, it's fine, but it's quite clunky on the front end. It takes a little while to get to grips and I feel the students go, "Oh, ePortfolio, here we go". But through what we've done in impact projects, now we've got quite a funky looking ePortfolio page. It was a Mahara template page that students are using and I think that it is working better.*

This teacher also used the ePortfolio for Professional Inquiry to keep a record of her aims and achievements for teacher certification/registration purposes.

While students were very competent at using Web 2.0 social networking tools such as Facebook, Flickr and Tumblr, Teacher Four's students struggled when asked to format a document in a word processor or spreadsheet application. Students viewed Google Docs as being the equivalent of an office productivity application, but the tools in Google Docs are limited.

Regarding students being exposed to industry-standard software, Teacher Four could see both points of view. It was considered important that students were exposed to the software type rather than specific industry standards. "I would say the technology supports the pedagogy rather than the other way around. In terms of teaching, I would think about what I was teaching and then how best to implement it." Her teaching always came first and then she would ask how the open source software could support it.

In terms of recording learning achievements, Teacher Four preferred her students to take a sample of their work (e.g., a sewing stitch sample), cut it out, stick it into a work book and write a comment rather than photograph it and upload it to an ePortfolio. ePortfolios were used extensively for the Impact Projects.

For student design work, students used the open source equivalents from the school network, namely, Inkscape, and GIMP and Google Sketchup. Teacher Four's students did not encounter problems with picking up new software and working with it. The design software was freely available for all students with no licensing restrictions.

Another Web 2.0 tool that Teacher Four had found very successful was YouTube, which was used for engaging students in design concepts from experts globally. She gave the example of a Dulux clip which showed colour use around the world. Short clips showed key elements very clearly, could be easily shared with her students or shown in the classroom, brought experts into the classroom, and used global teaching ideas.

4.5.3.5 Teacher Five

Teacher Five has fully engaged with open source software, using the school Edubuntu laptop for all of her teaching planning and administration. "Since I've been here, I've immersed myself in open source software. I don't use anything else. I've literally given my laptop to my husband and I just use the school one and it's just all open source anyway." Open source software was used in all her curriculum areas:

> *I use GIMP editing software for photography and design. I use Scribus for formatting and setting up photography and design boards for printing out later. I also use Inkscape in design for doing vector images and for logos and so forth.*

Regarding her use of open source graphic software with students, Teacher Five felt that she needed more experience in using it to fully support her students with their learning. Her experience with Photoshop and Illustrator meant she had previously compiled tutorial resources that were not applicable to open source software such as GIMP:

> *If students need any help I will help them to the best of my ability, but I feel that I am lacking. As far as resources and things like that go, trying to make resources becomes difficult because there's less information out there about what to make, etc.*

Teacher Five's department had made a Google Doc with links to tutorials on YouTube on open source graphics software. This teacher stated that the end result with open source graphic software was the same as with proprietary software, but the teaching was more time intensive. The school had employed a graphic designer to run some workshops on GIMP, which were effective, but the programs were extensive could not cover everything. The tutor was able to provide extra resources that were helpful.

Teacher Five found that some students coped with open source graphics software better than others. There was a broad spectrum ranging from students who relished the opportunity to learn other software to those who struggled with completing tasks. This led to frustration and impacted their learning. Professional development was important for developing skills in using the open source software.

The school was flexible and allowed students to bring their own laptops and use their personal copies of Photoshop to complete their work. This demanded more teacher time to teach two different software programs at the same time. Teacher Five estimated that half of the students in the class used their own copy of Photoshop and the other half used open source GIMP and Inkscape. Compatibility was a problem when transferring files between Photoshop and GIMP, with loss of layers, among other things.

Students brought their own devices such as smart phones into class and used them to search for information related to the topic of study. Tablets were also used to search for information, they had the ability to print any important documents, and students could easily write notes.

Teacher Five used Facebook personally but did not use it in the classroom. As a second-year teacher, she wanted to become more confident with the use of OSS before integrating Facebook. Teacher Five did see potential in the use of Facebook to enable students to draw something at home, share it on Facebook and get instant feedback from other students.

The Mahara ePortfolio software was used for beginning teachers to upload and share teaching competency evidence. The teacher uploaded reflections and teaching planning documentation for a mentor to view and give feedback in Mahara. Teacher Five found the use of the ePortfolio software straightforward because it is based on icons and tutorials were available.

4.5.3.6 Teacher Six

Regarding the use of OSS in his teaching practice, Teacher Six viewed collaboration as the most important factor. Whereas Teacher Six stated that open source is much more than just a collaborative and sharing space, he felt his students perceived it as simply providing access to the internet. Because students had difficulty opening documents that had been created with open source office software, they usually used proprietary software at home. With students' mindset of only using proprietary software, Teacher Six felt that most of students restricted themselves to using Microsoft Word and were not sufficiently open to using OSS alternatives.

Teacher Six could not give any specific examples of using OSS in his classroom. He used Google Docs, which is not technically classified as open source software, because students had difficulty opening documents using open source office software if they had that had been created with Word.

Students were observed by Teacher Six making extensive use of social networking software such as Facebook and Google Docs to share their work with the teacher for feedback. Teacher Six also acknowledged the printing problems associated with documents created in Libre Office because he had been unable to print examination papers using the school network system, which meant that he had to email them to his home address, format them using his Mac computer as PDFs, and then email the documents back to school for printing.

Teacher Six had experience in using the OSS Moodle Learning Management System (LMS) in schools, but he tended to use it as a file repository for students rather than as an integral teaching tool. He observed that few students logged into their Moodle accounts and therefore felt that the teaching culture needed to change before Moodle could be used effectivity in the school:

> *It's proved to be quite difficult. If a teacher makes Moodle or an intranet exciting and dynamic, then the pedagogy has to shift from being a chalk-and-talk-at-the-front type teacher to being a more of a facilitator, a guide on the side.*

Because he had tried to change his pedagogy but had encountered resistance from both students and parents, he believed that the solution lay in a professional development course for teachers on the effective use of online learning management systems and changing their pedagogy to online. Teacher Six felt that there was a need to change other aspects of teacher pedagogies at the school, that teachers should concentrate on teaching, and that there was potential for specialists to create online pages for teachers to use. “What you need is someone to be employed to set it up, a Moodle creator if you like, and the teacher would then facilitate the learning through the site.” If the school Moodle was linked to assessment, then students would buy into to it.

When Teacher Six used a Web 2.0 tool to allow students to use their mobile telephones to text a question, this had worked well because students still perceived mobile devices as involving fun and not related directly to learning. The exception to this was when the use of a mobile device was related to assessment.

Regarding the influence of open source software on classroom pedagogy, Teacher Six said: “I’ve tried some applications, but I don’t feel that I’ve necessarily been driving my learning through open source software.” Regarding pedagogy, he saw engagement as a big issue. “I say to students, I’m fighting the Candy Crush of meaningless game apps”. Teacher Six had changed his teaching style by reducing his talking time in class by dividing time up into quarters: 25% of the time speaking to the class; 25% moving around the class checking; 25% for students to work independently; and 25% for going back to check in with students again. Students used their own devices for connecting to the web, locating resources and working in Google Docs.

4.5.3.7 Teacher Seven

Teacher Seven used Google Docs extensively with her students to allow interaction in real time for feedback and online learning conversations. “I can comment on the work, they can reply back to me, and we can have conversations about their learning and their progress at times that are suitable for me and suitable for them.” Teacher Seven used Google Forms to get student feedback on her own teaching practice so that she could make improvements for the future:

> *I’ve just done my first form so I can get feedback from students anonymously. I then see their comments on me as a teacher and how I’m doing and their views on a unit that I’ve taught. I can collate those things quite easily. It’s actually making my life easier and therefore I think I can be more effective.*

Teacher Seven assumed that all of her students would be confident in using Google Docs but, after asking them to make a reflective document, she found that some students needed extra support to create the document and share it with her. Because not all the students were IT literate, she needed to keep this in mind for the future.

Using peer support to learn the technology was important for Teacher Seven. Colleagues in her department were very supportive and she found "just in time learning" of value. She also viewed the school as a creative environment with an open culture that encouraged creativity. She had observed students creating projects in a way that she had not experienced in other schools. Having Impact Project time was important and she had watched students teaching themselves OSS which they could then apply in their project (e.g. CAD open source software).

Although a team leader, Teacher Seven did not feel technologically literate and referred teachers to experts who could answer their queries. The school culture was one in which it was all right to say that "I don't know" and to refer on or investigate for oneself. The teacher's role was as a facilitator. "In fact, it's quite an important thing to be able to show that you're not the font of all knowledge as a teacher and to be open about that. I think that's positive."

Teacher Seven used her school Edubuntu laptop for teacher preparation and lesson-planning, but used Mahara ePortfolio software for her own professional inquiry and reflection. After surveying English classes, she found that 99% of students brought their own devices into the classrooms and thought that this was very positive and freed up school computers. She felt that it also altered pedagogy in the classroom, allowing students to research information during of a lesson, with students and teacher constructing learning together:

> *Hugely positive. BYOD is the modern equivalent of people who daydream and look out the window. It's going to happen sometimes, and it is part of good classroom management strategy. As a teacher, you still have to be onto what your students are actually doing, whether their device is helping their learning or whether it's actually: "Guys, let's put our devices away because at the moment I want you to be focussing on this other thing that we're doing over here."*

Overall, Teacher Seven had a very positive view of technology integration and, even though she felt that she lacked ability, she was willing to try anything to improve her practice and her students' learning.

4.5.3.8 Teacher Eight

Teacher Eight used OSS on a school laptop to create teaching resources for the classroom, while students used their own devices or school computers to create documents. This teacher did not mind whether students used OSS or proprietary software. The main software used by both students and the teacher for creating documents was Google Docs, with the teacher using it for communicating, giving feedback and storing and retrieving students work. The teacher was able to comment on and keep track of students' work in his own time.

Teacher Eight did not receive any handwritten work; it was all in electronic form. With the majority of students being competent in the use of technology, students who struggled with handwriting found typing and using word processors easier. Many students brought to class their own devices, such as mobile telephones or laptops. "It makes for quite a modern learning environment where students can access information that I've put forward via their devices and then create their own responses to their own work."

This teacher used multiple ways to provide information to the students, including Moodle LMS, ePortfolio and the school WikiEducator website:

> *If I have notes in class that are in electronic form, I'll put them on our intranet page. There'll be a topic that we're learning about at the time or a standard that we're looking at, for example creative writing. Then any electronic resources that I've used in class is posted there. So, if students miss a class, they can go and check it out.*

He also used a Facebook page to include links, related media material, reminders and notes about work that was due. "I also have a Facebook page as well to back that up, but usually what I'll do is use the Facebook page for links or related media material."

Teacher Eight explained that students were continuously on Facebook when using their laptop, tablet or smart telephone and were alerted to any notifications or alerts instantly. Therefore, he felt that Facebook was an efficient medium for instant communication with students:

> *Because it's so ingrained in them to check any notification that instantly pops up, a lot of them will have Facebook open or at least a tab open on their phones or on their computers. Whenever they hear the Facebook notification sign, they'll always go to look at it. You can post a reminder about the exam*

on Friday and at least a half of the class will have checked it within a couple of minutes.

This teacher felt that students did not differentiate between their social space and the school space on Facebook. He also stated that the Facebook page was like a virtual representation of the classroom situation in which students posted things and discussed topics together. The Facebook page also was more informal than the school environment.

The main advantage in using software for learning was considered to be the range of options available for teachers, whether using OSS such as Moodle for the intranet, Mahara for ePortfolios or cloud-based software such as Facebook or Google Docs. The software was flexible and easily accessed by both teachers and students via the school Wi-Fi.

The school was flexible with regards to software and if the students wanted to edit movies, there were specialist Mac computers loaded with iMovie and Final Cut Pro, which are proprietary software. The ePortfolio software was used by students to collect their electronic resources into a central place for assessment and to receive feedback from teachers. Google Docs was also linked to each student's Mahara ePortfolio collection and shared with teachers.

4.5.3.9 Teacher Nine

Teacher Nine, an accounting teacher, had a school laptop with Edubuntu and Libre Office installed, used Impress software for classroom presentations involving a data projector, and used Libre Office word processor software to prepare classroom handouts. This teacher had looked into using spreadsheet software but explained that accounting now involved more analysis and report writing. Google Docs was used to give feedback to students. The school intranet Moodle was used as a resource repository for students to access documents after class or when they had been absent from school. The teacher expressed an interest in creating a Wiki page that the students could edit.

Teacher Nine felt that student access to software supported her teaching pedagogy, particularly access to Google Docs from any mobile device. Access to the internet had enabled the teacher to set more-independent student activities (e.g. sending students a link to a company report to analyse, post their analysis to a Google Doc, and share it with the teacher. She felt that this was an opportunity to provide a more learner-centred environment. "Pedagogy wise, a shared Google Doc provides more opportunities for individual learning and is less teacher directed and more learner directed."

The BYOD policy meant that most students brought their own device into the classroom. This had opened up new teaching possibilities for this teacher to provide sites such as Pop Quiz and Socrates that students could use on their devices to send in their answers to a class question which was displayed on a data projector in the classroom.

Teacher Nine had also used the strategy of asking students to summarise what they had learnt into text message length (160 characters) and then share it with other students via Twitter. They critiqued each other's summary to check coverage of the key points. Facebook was also used by this teacher to post links related to topics so that students could co-construct some notes on Facebook in groups to share.

4.5.3.10 Teacher Ten

Teacher Ten, a specialist in photography and design, had a very student-centred pedagogy that involved students directing their own learning and being given some choice in the way they learn. From a holistic view, this teacher believed that OSS gave students choice in software to assist their learning:

> *I think it gives students the flexibility to be creative and think about what they can achieve, rather than just being told how it is and what programs to use. In design, we present them with three or four different programs that they can use and it's about the tool or the task that they are doing. We focus on the tasks that they need to do and then they can use which type of program suits them best, which I quite like.*

Most of Teacher Ten's teaching involved a computer suite with students working on individual computers. Rather than teach the whole class step by step together, this teacher introduced students to tutorials on the skills involved in using the software, and then was able to roam and help with the skills individually as needed.

This teacher used a school laptop with Libre Office to design learning tasks for students, as well as WikiEducator and open source design and photography software that was loaded onto the school computers. For example, students were given the task of creating a poster for which they could choose between GIMP and Inkscape. Tutorials were available online on topics varying from what the screen looked like to how to design the poster. “So, all the tasks that are set in our course are actually around the open source software.” The teacher acknowledged that teaching the skill steps using open source software was more complex than with proprietary software such as Photoshop.

Teacher Ten discussed an example of teaching poster design. The teacher demonstrated the principles and then introduced the students to GIMP and Inkscape basics. Differences were discussed before students were given the option of choosing either one or both programs for designing the poster.

Comparing the pedagogy used at the senior high school with traditional teaching, Teacher Ten claimed that using technology in learning was more holistic in that technology supported learning rather than being an end in itself.

Teacher Ten mentioned that access to proprietary specialist software such as Photoshop and Illustrator would benefit all students because it was available nationally. He commented that, although OSS could be used by students, it led to more problems than with proprietary software, and it was less user-friendly, more clunky and more sophisticated in that it could import larger RAW file sizes. Some students struggled with open source whereas they would have been able to use the proprietary software with more ease. Teacher Ten had created extensive resources using the proprietary software because she felt that areas such as photography and design were a special case. She mentioned that many students brought their own laptops and had their own copies of Photoshop and Illustrator that they used in class. She made tutorials available for both the OSS and proprietary software.

This teacher did not use Facebook at all because she found that it distracted students from their learning. The intranet Moodle was used infrequently for uploading resources for students. Google Docs was widely for emailing individual students and giving feedback on student work.

4.5.4 Focus groups: Pedagogy used in classrooms by teachers in relation to OSS

4.5.4.1 Year 11 March focus group

Students in this focus group considered that Google Docs made it was easier to share documents and learn from other students' planning because they could start a Google Doc at school, save it to their Google Account, and continue working on it at home. Students did not have to email it home or worry about any compatibility issues. Google Docs also enabled them to use any device for working on the documents without software having to be installed on the computers. Google Docs was available to everyone in the school and it was the means by which the students shared and received feedback from teachers. Students also worked on documents as a group and collaborated:

> *Everyone is on at once making changes and seeing what everyone else is doing on the document. You can see who is editing the document in real time. Or you can make your text different colours to show what you have done.*

Before students came to this school, they had had the impression that the teaching at the school was technologically advanced and modern:

> *It was generally accepted that the school was very technologically inclined. But we didn't know what the school computers would have on them. We didn't know that the computers would be using a certain operating system or Linux or whatever. I just knew that the school used a lot of technology.*

Students discussed how the senior high school encouraged the use of technology, laptops and portable devices. Students saw their school as unique with its three 100-minute periods each day. They stated that there was a lot of verbal exchange in classes.

4.5.4.2 Year 11 October focus group

This focus group continued to discuss the advantages of Google Docs for supporting their learning at school, providing similar reasons to those given in the March interview. Google Docs had continued to play an important role in the Year 11 studies at the Senior High School. Of the 10 students interviewed, four used a tablet, five used mobile telephones and nine used a laptop to access their Google Docs school account. "There's the ability to already have the document elsewhere for live editing instead of taking time to take the file to upload and then have to download it again to access it here at school."

Impact Projects were mentioned as an example of students using computer software to help them to complete their projects. Impact Projects were "highly structured, project-based learning experiences that you develop in teams or individually with guidance from your mentors at school and in consultation with experts in the community" (Albany Senior High School, n.d.-d, para. 3). A variety of types of software was mentioned by students, including some open source, some personally-owned proprietary software and cloud-based software.

Year 11 focus-group students were asked about their Impact Projects and the software that they used for their projects. Table 4.2 summarises student responses and indicates that the main OSS used was Mahara ePortfolio which was compulsory for all students when planning, reflecting on and presenting their Impact Projects at school. The use of Google Apps for Education was also common amongst students. If proprietary software was used, it was on their personal laptop.

Table 4.2 *Software used by students during Impact Projects*

Student gender	Impact Project	Software Used		
		Proprietary software	Open source software	Cloud-based software
Male	Art	Photoshop	Mahara	Google Docs
Female	Social Psychology-poster	MS Publisher	Mahara	
Male	Military Prep School-report		Mahara	Google Docs
Female	Baking-Report		Mahara to publish photos	Google Docs
Female	Teaching Leadership Report		Mahara	Google Site
Female	Rugby Nutrition Interviews Report		Mahara	Google Docs
Male	Theatre experience: did not use computers		Mahara	
Female	T-ball competition organisation	MS Office	Mahara	

Within the focus group, all students used Google Docs to plan, create and share documents related to their study. An advantage for students was group collaboration during which they were able to give feedback in real time. Google Docs allowed students to work seamlessly between school and home, with documents also being shared with teachers for feedback and formative/summative assessment.

The school's policy was that all Impact Projects were planned and that feedback was provided through the Mahara ePortfolio. Students were frustrated with the layout and usability of the ePortfolio software and they felt that they needed instruction on how to use it and locate and fill in the teacher-supplied templates. "We weren't actually taught how to use it. Here is the ePortfolio, make it. It was like being thrown into the deep end." The students also stated that only one person could edit the template in real time, unlike in Google Docs:

> *You can only have one person working on it at the same time. Every time you hit save, it saved yours and wiped off what the other person did. Quite frustrating.*

Once the evidence for an Impact Project was uploaded, it was shared with the teacher via a secret URL so that feedback could be provided. Students found this method of feedback less useful than Google Docs feedback because comments for the ePortfolio were at the bottom of the page and not linked directly to the text.

Students indicated that they made very limited use of the Intranet open source software Moodle. Some students had accessed Moodle to download help files uploaded by their teachers or to check notices. Students were frustrated that they had been given very little instruction or guidance on how to use OSS at the school:

> *The biggest thing about open source is that, as we have a whole school full of open source stuff, it would be useful to be told about it, to have a little bit explained to us at the beginning of the year. We now know we have these resources that we can use, which is what we didn't get at the beginning of the year.*

When focus-group students were asked what they thought was the best thing about teaching and learning at the school, they identified the teachers, with reasons including being treated as equals and everything seeming calmer at the school. Students also liked calling teachers by their first names and felt that this demonstrated mutual respect between students and teachers. Students felt that they wanted to please the teachers rather than disobey them, and that they were given many choices and responsibility for learning. Regarding teaching methods, students enjoyed the hands-on learning in business studies:

> *The business studies teacher is using Lego to help us to learn about product creativity and mass production of product. So, we are using Lego to help us understand that. It has helped a lot. It is fun; you don't even realise you are learning a lot at the same time.*

Students felt that teachers empowered them to ask questions and drive their own learning:

> *Instead of being spoon fed, they show you two sides: you either try or not try. You have to ask the questions, they are not telling you. It's like preparing you for when you go to university. Instead of giving you knowledge, they are giving you a structure for how to gain that knowledge, the method to find that knowledge yourself.*

Teachers were very supportive of students and gave feedback to guide their progress. "The teachers are keeping an eye on what you are doing. Giving you help along the way." The school architecture included an open teaching space where up to three classes shared a teaching space, rather than using single-cell classrooms. Students were respectful of other classes and had learnt to concentrate on their own learning:

> *Out in the learning commons, you have two or three classes plus everyone else around because it is through a central corridor. Everyone else being around it just allows for better learning. Because people are more quiet, they kind of respect everyone a bit better. Now I can be more focussed because I am used to everyone being around. It is a lot easier.*

Students also commented that OSS fitted in with the open philosophy which was embedded in all areas of school life.

4.5.4 3 Year 12 April focus group

Year 12 focus-group students were in the second year of using OSS. They were aware of the large numbers of desktop computers loaded with OSS throughout the school to assist with their learning. Students acknowledged that the school encouraged them to bring their own devices to assist with their learning and that they had the option of installing Microsoft or Apple versions of some of the OSS onto their computers.

This focus-group indicated that students did not use the intranet software (Moodle) at the school because there was no reason to log onto the intranet. Students wanted all teachers to commit to using the intranet but there was little material loaded on it at the moment. They thought that there was potential to use the intranet, especially if all students and teachers had a clear educational purpose.

Mahara ePortfolio software was used by the Year 12 group to plan and get feedback on their Impact Project. Students used a template as a group or individually and the ePortfolio was accessible from home and school. Students also discussed their individual Impact Projects including which specific open source software they had used. One focus-group student had used Blender for 3D modelling. Scribus had also been used because it was more sophisticated for formatting text documents than other office alternatives such as Word.

Google Docs was used by all the students for their school work and the focus group liked the way in which teachers could comment and give formative feedback on their progress. Students commented that, even over the school holidays, they would still get online feedback from their teachers. Perceived advantages of Google Docs were that no software needed to be installed, students could work in groups to produce a shared document, and work could be saved automatically in the cloud to avoid being lost. Google Apps for Education was used throughout the school for learning and communication:

> *Everything in Google, like Google chat and email, is all really simple and so I personally just tend to go to that because all the teachers and students usually check their school email. Documents come through on email, and so I just tend to stick with that.*

Some teachers also used Facebook with Year 12 students who acknowledged that it is regularly used by most students and that a Facebook notification provides quick communication. Students stated that Facebook was often open in the corner of the screen: “We check our Facebook more regularly than we check our emails. Whenever everyone is on the computers, it is always Facebook. Even if you are not on it, you are on it!” Students believed that Facebook was acceptable at school if they were using it for communication to help with their learning.

4.5.4.4 Year 13 focus group

The majority of Year 13 students brought their own devices to school and had either a Microsoft or Apple operating system loaded. For this reason, most students indicated that they infrequently used the school desktop computers. Like the other year groups, Year 13 students used Google Apps for Education extensively within the school for the following reasons:

- brilliant for doing groupwork
- multiple editing at the same time
- good for feedback from teachers and they can add a note
- easy to share
- very user friendly
- has just the basic editing functions and not complicated
- not stored on your computer
- large space for storing files securely
- don't need a powerful computer to edit documents
- can be accessed from laptop, school computer, mobile telephone or tablet.

Students commented that, although they did not access the intranet (Moodle) every day, it was accessed for school notices (which were replicated on screens throughout the school) and those subjects for which resources were uploaded for students to access. Students tended to use the school Gmail accounts for notifications.

Students spoke negatively about Mahara ePortfolio software, stating that its interface was not user friendly, and noted that the main reason for using it was to plan and record progress on their Impact Projects, which was compulsory. "I made a Mahara Impact Project page but that is it. It is a great idea, but it is a bad interface. It is not the friendliest thing to use." Students were required to locate a planning template, fill in the aims of their impact project and then share this with their teacher. Feedback was then given by the mentor teacher to the student. Evidence of progress was uploaded throughout the project including videos, Tumblr links and YouTube. Links were used rather than uploading evidence into the ePortfolio because students found its menus and processes quite complicated:

> *You get the template copy and paste it into the ePortfolio. Then editing is a bit of a nuisance as well because there are quite a few menus you have to go through to edit a simple thing like a title. Edit this, then click on that, then erase the original text which is on the template. You have to change three things just to do one thing.*

Regarding the use of OSS for school subjects, students felt that the interface was dated, commenting that Libre Office was like older versions of Microsoft Office and that they had problems with formatting when transferring documents between the two.

The internet was slow during peak usage at the school and this frustrated students, particularly on Wednesdays when many students were accessing the internet for Impact Projects. Students downloaded internet resources into their Google Drive from home so that they could access the resources from school on those days.

When discussing specific OSS at school, several students commented that some software was good and suited their purposes, such as Insite Stats for analysing data sets, Blender for 3D modelling projects, Inkscape for design, GIMP for photography and Audacity for sound editing. Students acknowledged that there was a suite of Mac computers that had proprietary software loaded for high-end video editing and multimedia work because no equivalent OSS was available for student use.

Facebook was mentioned as being used by some teachers to provide resources and feedback to students in certain subjects. Students indicated that they accessed Facebook more frequently than the school intranet because it was more effective for communicating with other students. “With class things, if there is an assessment coming up like I had for Health last year and any students needs help, you can privately message them or put it on their Facebook page or something.”

4.6 Conclusion

In this chapter, results for answering the case-study’s research questions, especially stakeholders’ views of the implementation of OSS in the senior high school, were presented.

The school management and teachers had a sound understanding of OSS, with students’ understanding increasing across the three student year levels surveyed.

Rationales provided for the use of OSS in education were closely linked to the definition of OSS. Google Apps for Education, which was confused with OSS by both students and teachers, was used extensively throughout the school for learning in tandem with OSS on desktop computers. Proprietary software was used on student BYOD laptops.

The rationale for the use of OSS complemented the open philosophy of the school regarding its accessibility, freedom of use and ability to be edited/customised. Cost saving was significant for all stakeholders, whereas the social aspects of narrowing the digital divide was important to teachers and senior management.

Advantages and disadvantages of the implementation of OSS from stakeholders' point of view were presented. Senior management considered that advantages outweighed disadvantages because the philosophy and use of OSS supported the school vision of Nurture, Inspire and Empower to achieve highly and be good citizens (Albany Senior High School, n.d.-g). Teachers varied in their opinions of the advantages of open source software, with most teachers supporting the software as part of the school culture and adapting their teaching to suit. A minority of teachers saw a disadvantage in that the software did not reflect the industry standards in the IT context; however, they adapted using work-arounds. Students adapted to the use of OSS on the school computers and liked that it was the same on every school computer. Students and teachers had problems with file incompatibility between Libre Office and Microsoft Office software. Google Docs for Education was used extensively because it allowed multiple users and collaboration/feedback on documents.

Senior management stated that pedagogy at the school centred around using OSS as a digital tool that supported all students' learning. The flexibility of OSS gave students access and freedom to choose specific software to support their learning without financial barriers. The school's philosophy as an open school with open learning spaces, open networks, flexibility of BYOD student devices, Impact Projects and choice of subjects meant that OSS complemented the school culture.

Teachers varied in their use of OSS, with all teachers using the open source Mahara ePortfolio to record/reflect and showcase their students' learning, particularly Impact Projects (Albany Senior High School, n.d.-e). Technology teachers had some problems with OSS and used a work-around solution or proprietary software to support student-centred learning. All teachers used Edubuntu OSS on their school laptops for administration and document creation. Google Apps for Education software was used by all teachers for feedback and collaboration so that student learning was supported both in and out of school hours. In the design and graphics department, OSS graphics software was available for students to use on the school desktop computers to ensure equitable access. The school was open and flexible about which digital tools could be used to support learning, whether OSS or proprietary software from the student's personal portable device. Social networking such as closed Facebook groups was used by some teachers to support students. Technology supported pedagogy throughout the school. The school was flexible; if OSS was not suitable, then specific proprietary software was purchased for student use.

Students used a mixture of software types to support their learning. If suitable, OSS was used in Impact Project or specific curriculum areas. Through the use of BYOD devices within the school, students had web access to ePortfolio software and Google Apps for Education software, which was used by students for collaborative learning and for feedback from other students or teachers. While Google Apps for Education was used extensively for collaborative learning, the open source Moodle LMS software was underutilised by the teachers and students. Facebook was used extensively for communication and resources were shared in closed Facebook groups by some teachers.

Chapter 5 further discusses and interprets Chapter 4's results of the research into open source software in the case-study school. From analysis and synthesis of results, a set of factors are identified for successful implementation of OSS to support learning in the senior high school.

Chapter 5

SYNTHESIS, INTEGRATION, SIGNIFICANCE AND LIMITATIONS OF FINDINGS

5.1 Introduction

Whereas Chapter 4 presented the results of my research into the implementation of open source software in a senior high school, Chapter 5 discusses those research results in the context of the application of OSS to learning and teaching in the school. My main research question focused on factors that facilitate or impede the effective implementation of open source software supporting learning and teaching in a senior high school. Table 5.1 provides an overview of the main topics discussed in Chapter 5, together with how these topics align with my study's four subsidiary research questions.

Table 5.1 *Main sections in Chapter 5 and their relation to research questions*

Section	Research Question
Section 5.2: Stakeholder's perceived definitions and rationales for OSS.	RQ1: What do stakeholders perceive open source software to be? RQ2: What do stakeholders perceive are the rationales for the use of open source software?
Section 5.3: Advantages and disadvantages of OSS in educational context	RQ 3: What do stakeholders perceive are advantages and disadvantages of open source software in educational context?
Section 5.4: Pedagogy used in classrooms in relation to OSS	RQ 4: What do stakeholders perceive is the pedagogy used in classrooms in relation to open source software?

Chapter 5 synthesises and discusses my research results relevant to the implementation of OSS for learning and teaching in the light of current literature. The significance of these results is discussed from all stakeholders' perspectives and emergent patterns, principles and relationships are identified.

5.2 Stakeholders' Perceived Definitions and Rationales for Open Source Software

Section 5.2 focuses on the first and second subsidiary research questions regarding stakeholders' definition of open source software and the rationales for its use in the case-study school as reported in Chapter 4. Sections 5.2.1–5.2.7 discuss different stakeholders' understanding of OSS and rationales to support learning, whereas Section 5.2.8 identifies themes that emerged during use of OSS in the school based on stakeholders' opinions.

5.2.1 Board of Trustees' opinions

The parent-elected Board of Trustees (BOT) is concerned with the overall governance of a school. In Section 4.2.2 and Section 4.3.1, it was reported that two BOT members responded via email to a question about what OSS means to them. Their responses summarised in Figure 5.1

The figures in this chapter diagrammatically summarise main themes in stakeholders' responses reported in Chapter 4. Links between the responses and educational benefits for the school are indicated with arrows.

Figure 5.1 suggests that Trustees considered that the use of OSS within the school had implications for savings in the school budget. Also, they thought that the use of open source software on the school network enabled access by teachers and students to OSS that supported learning and teaching throughout the school.

Figure 5.1 indicates that two Trustees viewed OSS as being available for all students and teachers without payment and was also empowering for the school community because all students, regardless of income, had equal access to the software. OSS was also being constantly developed and improved by the OSS community, giving the school access to the latest updates at no cost (Figure 5.1).

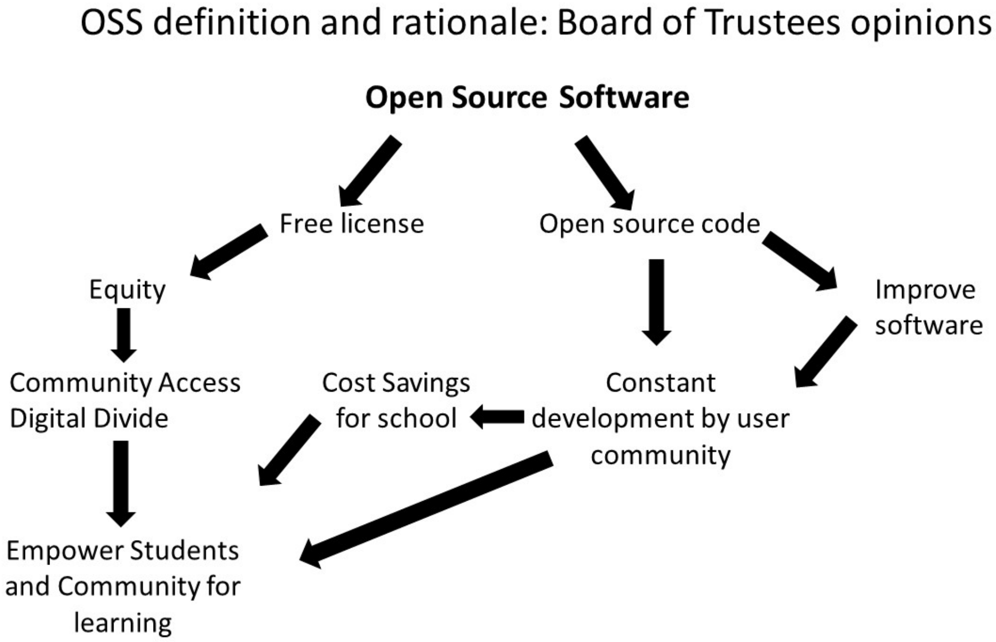

Figure 5.1. BOT definition and rationale for use of OSS (*N*=2; see Section 4.22 and 4.31)

Free redistribution and freedom to modify it are two fundamental characteristics of OSS (Open Source Initiative, 2007; Toro et al., 2020). OSS licences allow anyone to use and distribute it (Hansen, Kohntopp, & Pftitzman, 2002). The senior high school could source the software at no cost, distribute it freely to the students, and access a great variety of educational software across all school subjects using Edubuntu OSS (Edubuntu, 2016). New Zealand schools which use proprietary operating system software under the Ministry-funded agreement (Ministry of Education, 2021) use school funds to purchase specialist proprietary software to support specialist subject areas (e.g. Adobe Photoshop to support art and design students). The senior high school used open source Gimp and Inkscape software as an alternative to Adobe Photoshop. The Board of Trustees argued that the case-study school was freeing up funds to use elsewhere for the benefit of all students.

A BOT representative argued that free access to software gave all students equal access to it, thereby effectively narrowing the digital divide which is “the gap or imbalance that exists between those who have access to Information and Communications Technology and also to the unequal access of resources” (ICT4D, 2008, para. 6). Figure 4.11 in Chapter 4 indicates that 3.3% of students who completed a web survey were disadvantaged by having no computer at home, but they access to school computers. All students had the option to access OSS and the internet via the school computers. The school also had an open BYOD (Bring Your Own Device) policy which encouraged students to bring their own mobile devices to school. Figure 4.11 in Chapter 4 indicates that 87% of students regularly bring their own devices to school, with the school Wi-Fi being used by students to access online resources to assist with their study via their own devices.

Because the OSS was editable by anyone who has the skills, and improvements are fed back to the OSS user community, it is constantly being improved for the school's benefit (Section 4.2.5). At no cost, the school can offer students up-to-date software.

The IT school technician indicated that upgrades were usually installed during between-term breaks to minimise disruption for students. The overall costs for an institution can go beyond the initial purchase cost of the proprietary software. Raja (2000, para. 6) stated that "even Microsoft has reportedly conceded that, in line with the findings of a survey by the Gartner Group, the cost of software licenses amounts to only 8% of the total cost of ownership, and that the other 92% reflects the costs of installation, maintenance, management and repairs after failures". Further cost savings were made the school because installation of OSS was carried out by the school's IT technicians.

In terms of Twining's (2014) rationales for the use of ICT in education, the Board of Trustees representatives viewed open source software as supporting cost-effective education, pedagogy, transformation and the social good of the community. The pedagogical, transformational and social rationales support the principles and aims of eLearning at the school: "Our vision for technology at ASHS centres around the role it can play to achieve our vision: To nurture, inspire and empower students to achieve highly and become good citizens". (Albany Senior High School, n.d.-c, para. 4). The annual report for Albany Senior High School Board of Trustees (n.d.-a, p. 5) stated: "The vision for our school is to serve our community and model best practice teaching and learning in our world class facilities." Because the choice of OSS also enabled flexibility and openness in choosing software (Dehinbo & Dista, 2016; Reisinger, 2016), budget restrictions did not prevent the school from changing software.

Overall, the BOT representatives surveyed were very positive about the use of OSS because it fitted into the school's open philosophy. The use of OSS, open plan learning commons, open teaching, open educational resources and an open interpretation of the NZ curriculum underpin all teaching and learning at the senior high school.

5.2.2 Senior management's opinions

I conducted face-to-face interviews with the principal, three deputy principals and the founding deputy principal, who was the driver behind the adoption of OSS in the school. The senior management team managed teachers to ensure the best learning outcomes for students and was responsible for pedagogy, including the integration of ICT into open teaching spaces throughout the school. Insights from these interviews with senior management were reported in Section 4.2.3 and Section 4.3.3 and are summarised in Figure 5.2.

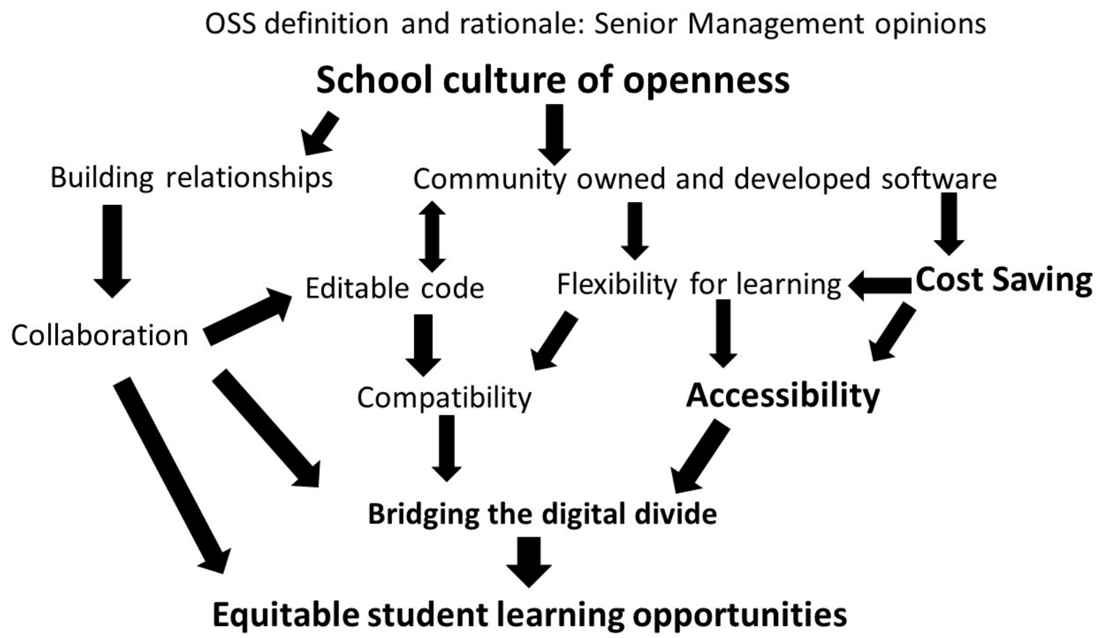

Figure *5.2.* Senior management's definition and rationale for the use of OSS in the school (*N* = 5; see Section 4.2.3 and 4.3.3)

Figure 5.2 illustrates senior management's commitment to developing an open learning culture and providing equitable learning opportunities for all students. OSS provided access to all students and removed barriers to learning. As an open learning community, the school benefitted from the ability to edit and improve OSS. The senior management team's rationale for choosing OSS as part of the school culture of openness was consistent with Westera (2005, p. 97) who stated that “the open source movement strongly exhibits the moral aspects of open source, while referring to the equality of human individuals and their rights for equal opportunities and accessibility to relevant sources”.

Senior management views aligned with the school’s understanding of OSS and fitted the open school culture. With building relationships through networking being a major aspect of the open culture of the school, the school’s network facilitated student and staff communication. School desktop computer pods for students were available throughout the learning commons areas. Osborne and Tucker (2010) noted that student-developed OSS was used within the senior high school for microblogging, social book-marking and digital display signage.

With the senior management being responsible for school budgets for teaching resources, cost savings with OSS allowed all students access to a large range of software subject-specific over the school network on the school computers, which is related to the accessibility rationale of Twinning (2014). In discussing the important contribution of OSS to pedagogy in the school (see Figure 4.15), senior management noted that OSS enabled student access to software to support their learning both at school and home. This is linked to Twining’s (2014) pedagogical and transformational rationales of the school’s vision (Albany Senior High School, n.d.-a) to nurture, inspire and empower the students’ learning. Albany Senior High School (n.d.-c, para. 1) stated that “we have put together a range of ICT tools and environments that help our staff and students to achieve our vision”.

Senior management’s rationale was to allow equitable access to educational software to support learning to all students irrespective of income (Dehinbo & Dista, 2016). Open access to software is linked to Twining’s (2014) rationale of bridging the digital divide. For the school principal, access to OSS removed barriers for learning regardless of their personal circumstances. If a student required access to specific software to assist with learning, neither finances nor accessibility was not a barrier. Teachers also had the freedom to install OSS on their teacher Linux-based laptops as required. The principal envisaged OSS as supporting personalised learning and for the development of autonomous learners.

Hipkins (2011, p. 12), in her research on the case-study school, noted:

The idea that energises this aspect of school life is the intent to foster agency and the development of greater autonomy in learning. Both students and teachers are supported to be self-directed in pursuing learning questions of relevance and importance to them, and to actively work to build meaningful connections and coherence across the breadth of their work.

The principal argued that OSS supported the school vision of nurturing (open communication between learners, home/school links, access to software), inspiring each other (supporting learning/inquiry within the school, collaborative learning and community of practice) and empowering students (supporting authentic learning, the community, celebrating achievements). OSS contributed to the development of an open school and 21st Century learners (Hipkins, 2011; Lane & Goode, 2021). The deputy principals perceived OSS as supporting the open philosophy of the school by allowing students to access digital tools in a just-in-time manner to support learning (Fullan & Langworthy, 2014) and enabled students and teachers to focus on the learning process rather than questions about whether appropriate software can be sourced, purchased and installed. Deputy Principals One, Two and Four emphasised that the knowledge and skills learnt while using the OSS were transferable to proprietary software (The Document Foundation, 2016).

Deputy Principal Two argued that OSS allowed students to work from both home and school using the same software at no cost and also can be installed on a variety of BYOD devices. Both Open Office and LibreOffice word processing suites were available for laptops, android phones and tablets. Robinson (n.d.) noted that LibreOffice 2015 has been modified for android devices and can run on iOS devices to allow students to install it on their mobile devices. Mendelson (2021) states that the latest Libre Office OSS app is available for Windows, macOS and Linux for all students to install irrespective of their devices' operating system.

Founding Deputy Principal Four stated that the school was preparing students for living in the future and that, in the long term, it is not important to equip students with skills in using specific proprietary software. Students need open access to software when required and to develop technology skills for future employment (Schinkten, 2017). Also Deputy Principal Four envisioned that learning in the future will involve collaboration and sharing knowledge which can be achieved with OSS such as Moodle and Mahara (Lakhan & Jhunjhunwala, 2008). Open source software supported the school's vision of nurturing, inspiring and empowering of the students.

This Deputy Principal's pedagogy is driven by constructivism which involves students constructing their own personalised learning environment supported by digital tools (Fullan & Langworthy, 2013).

Deputy Principal Four believed in learner-centred pedagogy and the role of ICT in supporting, not driving, learning (Rhodes, 2020). Therefore, flexible access to appropriate software was needed to support the development of the students' learning, which was central to the open philosophy in the establishment of the school. Wiley (2016, para. 4) stated: "The idea of 'open' intersects with education and educational technology in many places – open content, open educational resources, open access, open data, open knowledge, open source, and open standards."

With the senior management team's aim of embedding an open learning culture within the school, OSS fitted the concept of open education which also encompassed open educational resources (OER), open teaching spaces, and open and collaborative teaching practice. Open education is "a global movement working for universal access to education" and it "works to make educational resources more accessible and more affordable" (Creative Commons Aotearoa New Zealand, 2016, para. 1). In the context of open education, open source software allowed access to educational software resources for all of the school's students. Overall, senior management viewed the use of OSS as supporting the school's vision and rationales Twining's (2014) rationales of pedagogy, digital divide, cost effectiveness and transformation.

5.2.3 Teachers' opinions

When I interviewed 10 teachers, their responses were reported in detail in Sections 4.2.4 and 4.3.4 and are summarised in Figure 5.3. This figure shows that openness was considered important by teachers for supporting the learning community in the school. OSS is available at no cost, giving the school the choice to install it on the school network for student and teacher use. Teacher pedagogy was also supported through providing digital tools to support the learning for all students in the school (Fullan et al., 2020). Accessibility was a major rationale for the teachers in that all students had access to the software. Some teachers mentioned the ethical factor of community-based software being free from corporate control. Amongst technology teachers, there was some debate about whether students should be using software that they wouldn't use in their careers.

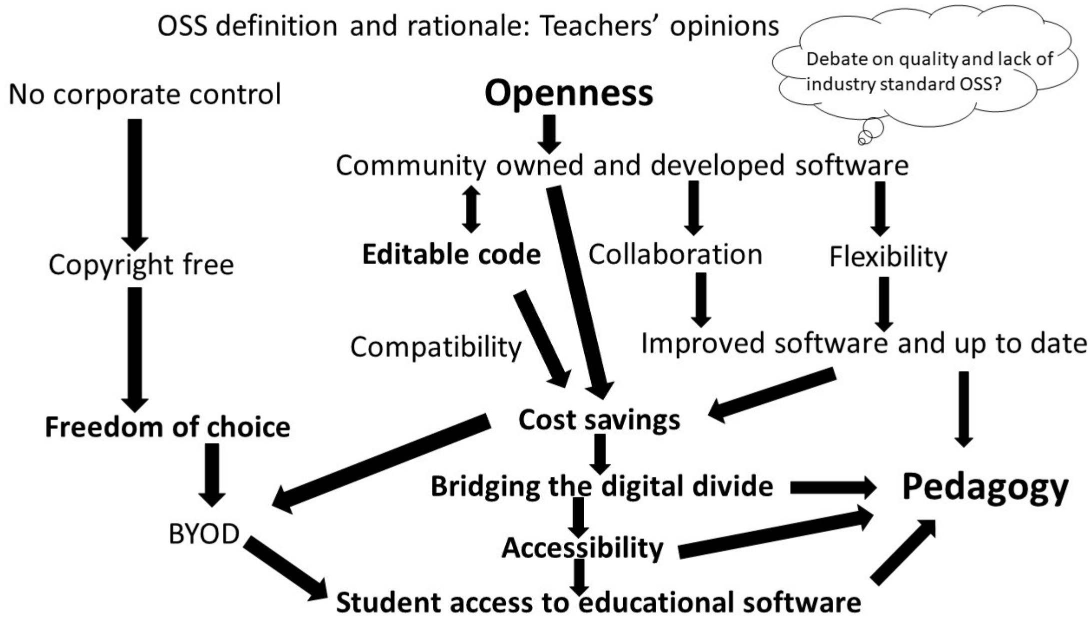

Figure 5.3 Teachers' definition and rationale for OSS (N =10; see Section 4.2.4 and 4.3.4)

Cost savings were a major rationale for teachers because they enabled the school budget to be spent elsewhere for the benefit of the students (Singapore Management University, 2014). Board of Education of School District No 73 (2012) listed OSS cost savings as a major benefit for schools, including savings on licences and virus software on the networks, and also noted that the availability of OSS reduced software piracy amongst students. Laden (2010) and Reisinger (2016) report that Barriere Secondary School and the Penn Manor School district saved considerably on hardware, software licensing, maintenance and electricity.

The case-study school chose not to sign up for the Ministry of Education (2016) software agreement which gave New Zealand schools free access to operating system and office software from Microsoft, Apple, Novell, SketchUp-Pro, Websense and Symantec Antivirus software. But the school had signed up for Google Apps for Education, which was provided at no cost to all NZ schools to provide access to an educational suite of closed source cloud software. Opensource.com (n.d., para. 10) stated: "Cloud computing applications, like Google Docs, are closed source programs."

Like the other stakeholders, teachers stated that use of OSS improved student access to educational software to support learning (see Figure 5.3). The greater good of the student community was improved because all students had equal access to OSS or Google Apps for Education. However, one teacher questioned the quality of OSS for his special subject area (digital technology) and felt that students should be familiar with proprietary software used in industry. In the literature, both open source and proprietary software have recognised advantages (Optimus Information Inc, 2015; Pankaja & Mukund, 2013; Pianon, 2004; Trappler, 2009;). For example, Deputy Principal One noted that the school's media studies department has a small suite of Macs to run proprietary Final Cut Pro video editing software because an equivalent OSS solution could not be found.

The teachers' main rationale was pedagogy (Fullan et al, 2020), with students' use of OSS being to manage, organise and enhance their learning (see Figure 5.3). Teachers commented that open source software was compatible with the school vision to nurture, inspire and empower, with the role of ICT being to enhance and support learning where appropriate. The contribution that OSS makes to learning is very difficult to assess because so many variables make up successful learning (Cuban, 2020; Trucano, 2005). Pfaffman (2008, p. 28) notes that "it is not yet clear that using computers in classrooms results in increased learning" and discusses studies of how access to computers affects student learning.

Twining's (2014, para. 15) social rationale was described as "preparation for living in a society that is permeated with technology". Teachers considered social learning as very important because students use ICT to collaborate and work together on group projects. Gage and Berliner (cited in Roblyer, Edwards, & Havrulik, 1997, p. 66) stated that "Vygotsky felt that cognitive development was directly related to and based on social development". This was important in the context of the case-study school because the high use of social networking software and the high percentage of BYOD devices allowed blended face-to -face and online collaborative learning.

Although teachers had a wide variety of opinions about open source software, they all considered that OSS is community developed with editable code and that improvements are shared with the community for anyone to download and use. Teachers also differed in their integration of OSS, but they all agreed that using OSS was compatible with the school's philosophy on open education: OSS enabled cost saving and equitable use for all students.

Some teachers with specific software requirements considered that available OSS was unsuitable for classroom use. Compatibility was an issue for technology teachers (see Figure 5.3); for example, controlling a programmable logic controller (PLC) is very difficult without specific proprietary software. Technology teachers were able to find solutions for their problems by using personal Microsoft laptops. As an alternative, the British Broadcasting Corporation has given one million British students a PLC device for learning beginning programming. EdSurge (2016, para. 1) states: "It's hardware is open-source and designed for students with no technical experience to be able to use and customize it." Devices such as the micro:bit would negate the use of proprietary software through programming via a web browser. Another solution would be for the school to purchase a computer on wheels (COW) setup with Windows-based laptops used with the PLCs when needed, which is similar to the media studies solution with Macs/Final Cut Pro software.

When one teacher had tried OSS for computer-aided drawing (CAD) and web design, it was found to be dated and unstable. His opinion was that specific proprietary software would be more stable and more relevant for students and should be provided on a case-by-case basis when OSS is unsuitable. Autodesk (n.d.) advises that Autodesk CAD software is available free for all educational institutions worldwide, but that it only runs on Windows or Mac computers and produces a watermark on all projects. This would be a possible solution for the CAD teacher if suitable COW Windows-based laptops could be made available within the school. Another alternative would be to try out a variety of open source CAD programs until a stable version is located to run on the school network. Baker (2017) investigated open source CAD programmes and listed Salome, BRL-CAD, FreeCAD and LibreCAD as alternatives to AutoCAD. Baker (2017) noted that BRL-CAD in particular was very stable with more than a million lines of source code.

Some teachers confused cloud-based closed source software such as Google Apps with open source software. Google Apps was used extensively by teachers and students for email, word processing and collaborative projects using Google drive cloud storage. With Google Docs, teachers valued the ability to work anywhere and give feedback on mobile devices. Brown and Hocutt's (2015) usability study with Google Apps for Education (GAFE) revealed that students considered the most-useful functions of GAFE apps to be sharing of documents, the commenting function and collaborative features. The cloud-based browser interface was also considered very useful because it allowed accessibility over a wide variety of portable devices from any location providing there is access to Wi-Fi or a mobile network (Brown & Hocutt, 2015).

Teachers working in graphics and design had persevered with the open source equivalent software such as GIMP (GIMP, 2022) and, although more steps were needed to achieve the desired result (compared with Photoshop), they were satisfied with the software. Teachers voiced their concerns about OSS not being used widely in industry (see Figure 5.3). The use of specialist graphic OSS meant that all students had access to software that could be installed on both OSS computer operating systems and proprietary computer operating systems. Dove (n.d., para. 27) noted that GIMP "is free and lets you accomplish much of what you can in Photoshop and the shortcut keys are the same. While the interface is improving over time, is not nearly as elegant or intuitive". Both teachers and students reported that they had some difficulty with GIMP's user interface.

Teacher Six identified a mind-set amongst students about the defacto use of proprietary software because it was pre-installed on personal student laptops when purchased. This teacher felt that cloud-based software had an important role in the school, particularly with student mobile devices and social networking for communication and collaboration. Cloud-based software, particularly productivity apps (Google Apps for Education) and social networking apps (Facebook Messenger, WhatsApp, Snapchat and Twitter), is available for all portable student devices, therefore reducing student use of OSS which was limited to school desktop computers.

When the teachers used OSS on their teacher Linux-based laptops for administrative purposes, few problems were encountered with software such as LibreOffice, except for some compatibility issues with files in Word doc format. Regarding communicating and providing feedback to students, the cloud-based closed source software Google Apps including Gmail was used primarily by all teachers in the classroom. Interestingly, teachers reported that students responded more quickly to Facebook messenger compared with email. Digital technology and graphics teachers encountered some problems when using the equivalent industry-standard OSS in their classes. Graphics teachers had persevered in using OSS graphics software with their students. Specialist digital technology teachers had encountered major problems because hardware used in digital technology such as PLCs are designed to only accept proprietary software. The technology teacher using Web-design software, CAD software and project management software felt that OSS equivalents are underdeveloped, unstable and unsuitable for classroom use. All teachers in the school had made adaptions to their teaching to allow the integration of OSS in their classroom.

5.2.4 IT technician's opinions

My interview with the IT Technician was reported in detail in Sections 4.2.5 and 4.3.2 and is summarised in Figure 5.4. This figure illustrates the IT technician's role in providing support for the installation and use of OSS on the school's Linux network. Following requests from teachers, students and senior management, the IT technician installed OSS, managed upgrades for existing software and provided trouble shooting for any network problems. The open source community was used as a resource for any OSS problems or improvements (Chawner, 2021).

Email within the school is managed by Google and students have access to the Google Apps educational suite. Google Apps for Education was a major cost and time-saving tool for the IT technician because he could concentrate on managing the school Linux-based network and distributing OSS.

Penn Manor High School (Reisinger, 2016) also uses OSS and supplies each student with a laptop running with the Linux Edubuntu operating system. Penn Manor High also utilises an OSS network, Edubuntu OSS programs, and student apprentices to configure and maintain student laptops (Reisinger, 2016).

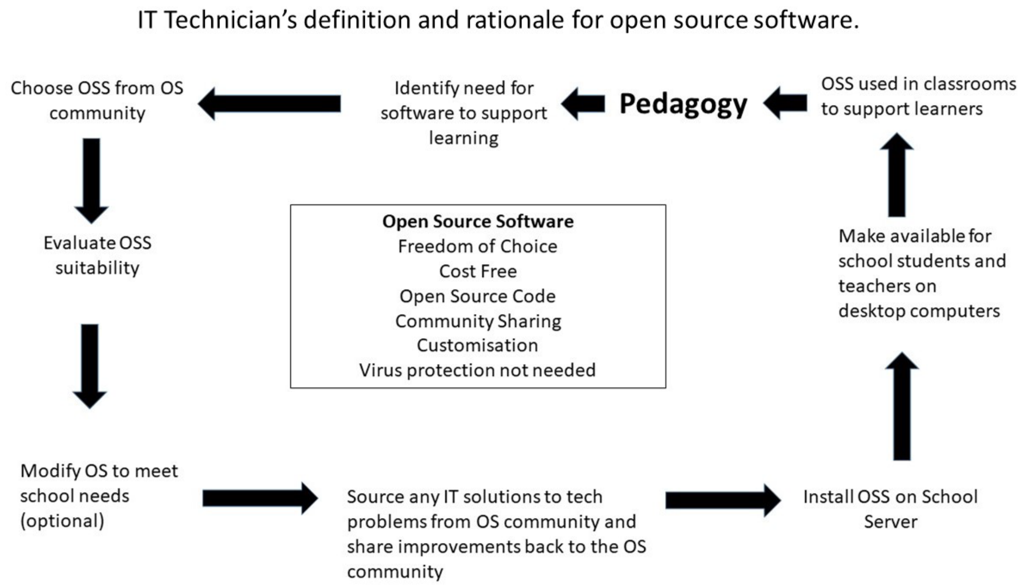

Figure 5.4 IT technician's definition and rationale for OSS (N=1; see Sections 4.2.5, 4.3.2)

Figure 5.4 illustrates how, according to the IT technician, the choice of OSS allows the school to choose, install and test OSS at no financial risk (Stallman, 2021b). If the software does not have the features that the school requires, then it can modify the code and add the features (Stallman, 2021b). Reisinger (2016) stated that OSS gives Penn Manor High the freedom to customise the laptop operating system and install educational OSS as required. Regarding the OSS library software Koha (Koha, 2022), the IT Technician noted that a software programmer was employed to modify it to include bookmarks and favourites which were uploaded to the Koha community to share. Doesburg (2010) reports that Koha is open source library software that was developed in New Zealand, is used in libraries throughout the world, is dynamic, and evolved from a small New Zealand town library's needs. Koha has a vibrant developer base to serve the needs of libraries throughout the world (Koha, 2022).

Mittal and Singh (2013) listed the advantages of OSS as right to modify code, redistribute modifications, have no vendor lock-in, and allow constant development, upgrades and scaling. The case-study school students developed their own software applications for the school network, such as the news app for displaying school news on school television monitors. Penn Manor High's students also develop OSS tools for use throughout the school (Reisinger, 2016), such as a help desk programme that was coded by a student and deployed throughout the school (Reisinger, 2015b).

The IT technician identified many advantages of the school's use of the open source software Edubuntu, particularly its stability of the school network (Figure 5.4). No antivirus software is necessary because Windows-based exe files will not run on the Linux network. Noyes (2010) notes that five reasons why Linux is superior to Windows for servers are stability, security, hardware, lower total cost of ownership and freedom. These are important factors for running school network for which stability and continuity of availability are paramount during school hours, particularly because students make extensive use of Google Apps for Education.

5.2.5 Focus groups: Year 11 and 12 students' opinions

Data from students were gathered using two methods. First, focus group interviews were held with 10 students at each of level 11, 12 and 13 (Section 3.4.11) selected by the deputy principal to explore students' views of OSS. Second, a web survey (Section 3.4.2.3) involved all student year levels. The data from both methods were analysed using thematic analysis (Section 3.5.2) and coding identified themes discussed in Chapters 4 and 5.

Ten year 11 students were interviewed twice in focus groups (March and October). Because this was their first year at the school, the interviews were used to identify initial perceptions of OSS. Ten year 12 students were interviewed once in focus groups. Findings from these focus groups were reported in Section 4.2.6.1 (year 11) and 4.2.6.2 (year 12) and are summarised in Figure 5.5.

Figure 5.5 shows that year 11 and year 12 students viewed OSS as being cost effective, being accessible for all students, supporting student use for learning (pedagogy), and being user friendly. Year 11 students' interpretation of OSS did not change between the March and October interview. Discussion of the definition of OSS was dominated by male students who identified ease of access, being able to edit the software code, and its openness (Figure 5.5).

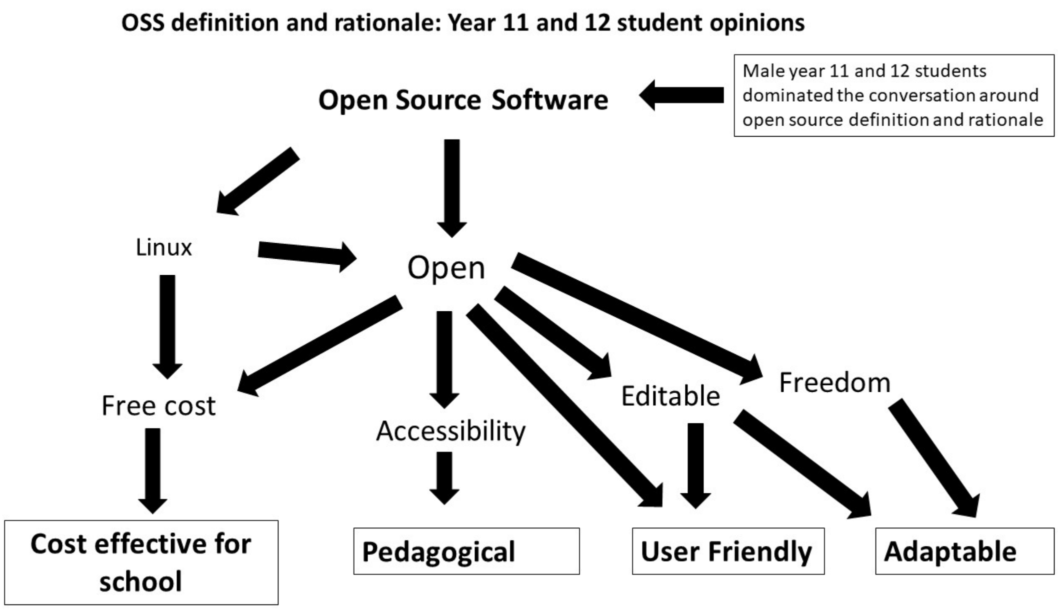

Figure 5.5 Year 11 and 12 students' definition and rationale for OSS (*N*=20; see Sections 4.2.6.1, 4.2.6.2 and 4.3.5)

Year 11 and 12 female students were reticent about OSS and unaware of its meaning. An interviewee in Weaver and Tucker (2002, p. 23) stated: "Women are excluded from the 'computer related' industries early on. The marketing of computer games, computer hardware/software are aimed at men. This creates a man's world." Morton (2013) found that, because ICT subjects at high school are mostly concerned with unit standards and typing skills, female students are discouraged from furthering their skills with ICT and they lose interest. Curtis (2015, para. 2) reports that a study from the NZ Ministry of Education found "proportionately, girls who enter for NCEA digital technologies' achievement standards, outperform boys at every level. The problem is getting girls interested in IT."

The discussion of the meaning of OSS was dominated by year 12 male students who demonstrated a good understanding and indicated that they had some experience with OSS and had installed OSS on their devices.

Year 11 students were vague about their previous experience of using OSS before coming to the senior high school, confusing it with closed source cloud applications such as Google Docs. An understanding of OSS was not important to students because they were focussed on using it to assist their learning. Easy access to the software was important through the use of apps on their personal devices or the school computers.

Year 11 female focus-group students were reluctant to discuss their previous experience of using OSS and lacked confidence in discussing technology related to it in the school. Becta (2008, p. 3) found: "Although there is little evidence that girls are less skilled than boys in the use of ICT (indeed, in some areas they show greater skill), girls generally feel less confident in their ability to use technology." Becta (2008) also reported: "Whereas boys are interested in technology for its own sake, girls see ICT as a means of pursuing their interests and furthering their learning." Becta (2008) also stated that, as girls progress through the school system, they become less interested in technology, which is consistent with my findings in this study. Ardies et al.'s (2015) study of boys' and girls' interest in technology at schools revealed that interest in technology decreases as students progress through high school, therefore highlighting a need for schools to promote technology as a career.

A student commented about the desktop computers in the school being loaded with a lot of software: there was no risk in the installation of new OSS on the school servers because there was no financial commitment to use it even if it was unsuitable for the original educational purpose (Toro et al., 2020).

When new educational open source software was located, it was emailed by students or teachers to the IT technician who vetted it, consulted the Deputy Principal and then installed it on the school network. During the writing of this thesis, I sometimes located educational OSS that could be useful for the senior high school. For example, when I located sketching software named Krita (Kritia, 2022), I received the following response from a Deputy Principal "It's already there! I think one of our students found it last year and went to our IT staff, who kindly installed it for us." Datamation (2015) listed over 1200 open source software applications that were available to download. Wikipedia (2021d) had an extensive list of open source software currently being developed for education. Tong (2004) also commented that there is a large amount of educational software available. The just-in-time OSS capability suited the needs of students involved in Impact Projects at the school. For example, the Deputy Principal commented on the use of Audacity sound recording software used by a student in her inquiry.

Year 11 students reported that, although they were somewhat confused at first with the Linux operating system, it did not take them long to become familiar with the interface after peer support. Thornburg (2007) reported in his study of a Michigan City High School that, of the 26 students surveyed, two thirds did not realise that they were using the Linux operating system. “It shows that Linux is clearly ready for use on student desktops, and that there is little to no learning curve involved in its use, especially since the bulk (23) of the students are using Windows at home. This observation is significant” (Thornburg, 2007, p. 4).

Most students in the focus group had the Microsoft operating system loaded on their home computers and used Microsoft Word for word processing, after encountering problems with OSS when emailing documents and presentations between home and school. LibreOffice tended to change the format of original documents or not open the Microsoft documents or PowerPoint files. Klosowski (2013), in comparing Microsoft Office and LibreOffice, could not find much difference between the two regarding features. “If a word processor is all you really need, then Writer will do everything Word can do and more” (Klosowski, 2013, para. 7). Since the time of the focus-group interviews, Libre Writer has been updated and can import and export Word documents with no loss of formatting (Ploshchad & Teppel, 2019; Reisinger, 2016). Microsoft Word now opens (ODF) Open Document Format files (OpenDocument Format, n.d.; Wikipedia, 2021f). Students reported that little support was given in the use of LibreOffice for the skills needed to import/export documents at school. Kadoodvand et al. (2017) suggest that a combination of teacher, school, peer and family support is vital for supporting student learning of ICT skills.

Year 11 students reported that the learning curve with the Edubuntu operating system was steep at first, but got easier with use. A male student reported that he had several programs on his own laptop and had taught himself how to use them and that he used GIMP for image editing. Pfaffman (2008) stated that one advantage of OSS is the freedom for students to install the same software as the school on their own computers, which is beneficial for both the school and students. Peer support is useful for learning new ICT skills (Kadoodvand et al., 2017) and is a time saver when students are completing school tasks at home in their own time.

Year 11 students stated that they used Google Apps for Education (GAFE) extensively to allow them to work seamlessly from both school and home, with cloud storage removing worry about saving/converting documents or using email or USB storage devices. Brown and Hocutt (2015, p. 1) reported: "Students found GAFE relatively easy to use and appreciated its collaborative affordances." The majority of students used their own devices at school and were able to edit Google documents from home or school.

Year 12 focus group reported little experience with OSS before attending the senior high school but that they were dissatisfied with the computers at their previous school (the local junior high school) which used proprietary software. Students complained about the lack of software available and that junior high computers were only used for presentations. Although the OSS Edubuntu interface was new to the year 12 focus group, male students reported little difficulty adapting and using Edubuntu on the school desktop computers (Thornburg, 2007) and LibreOffice (The Document Foundation, 2022), which is similar to older versions of Microsoft Word.

Year 12 female students had problems with LibreOffice, specifically file incompatibility between Microsoft Word on their home computers and LibreOffice on the school desktop computers. Female students in the focus group had difficulty saving a LibreOffice document as a Word document. Reisinger (2016, p. 102) stated that "support and training are critical to the success" when referring to the implementation of open source software into a high school. Becta (2008, p. 4) said: "Recent trends in ICT may prove particularly beneficial to girls: increasing use of social and collaborative technologies, a growing emphasis on ICT integration within subjects… both at school and at home, is increasingly aligned with girls' interests and preferences." During the focus group interviews, girls indicated that they made extensive use of Facebook and enjoyed the collaboration and social communication aspects of ICT. Carreon (2018) researched students' use of Facebook integration into learning and found that it allowed learners to learn according to their own pace, time and place. Facebook fostered motivation, confidence and student interaction.

5.2.6 Focus group: Year 13 students' opinions

Year 13 students were in their third and final year at the senior high school and had OSS for three years to support their learning. Figure 5.6 illustrates that both female and male students had a good understanding of the key attributes of OSS in providing all students access to free, customisable software, with the main rationale being to support their learning.

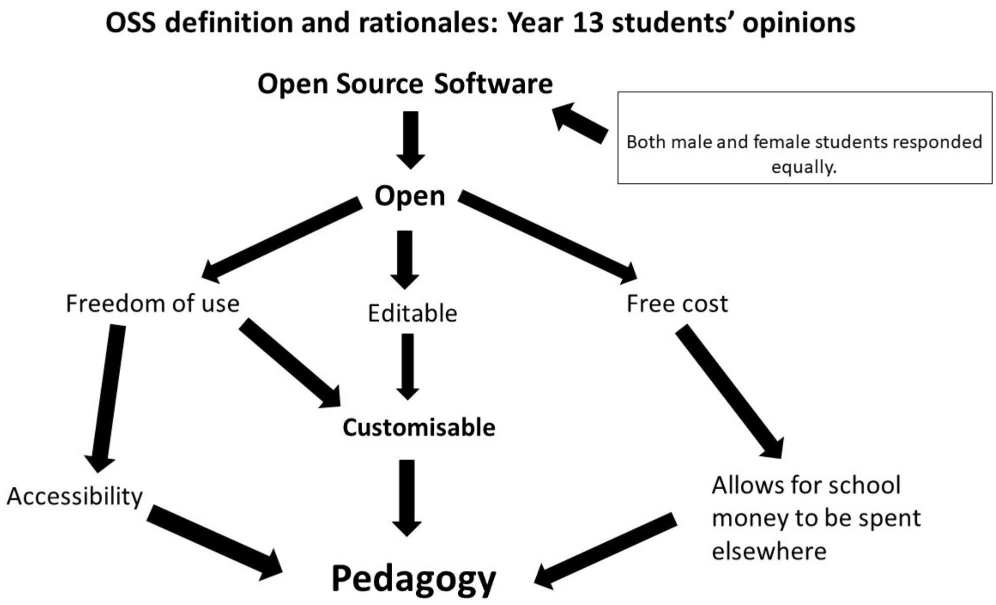

Figure 5.6 Year 13 students' definition and rationale for OSS (N = 10; Sections 4.2.6, 4.3.5)

In contrast to the year 11–12 focus groups, there was an equal contribution from the female and male students in the year 13 focus group. Raftree (2012) suggests that schools should consider improving access to ICTs, integrate ICT into learning and use female role models to change girls' attitudes. Students emphasised that the pedagogical rationale for the use of open source software was to support their learning in the school. OSS was part of the types (labelled a mixture in this thesis) of software used on the student BYOD devices to create "user generated content through social networking" and access to cloud apps (Male & Burden, 2013, p. 1).

Year 13 students had a good understanding of the principles of open source software (Opensource.com, n.d.) and how it can be applied to assist with their learning. OSS was accessible by all stakeholders in the school and students noted that OSS and cloud-based apps (Garov et al., 2018) were available outside the school to give students access to software at home to help with their studies.

Year 13 focus-group students indicated that, although they had little experience of OSS before attending the senior high school, they did not experience any problems in adapting to the open source interface on the school computers (Thornburg, 2007). Two boys had tried OSS at home, a student had installed the Linux operating system on his own computer, and another student had installed and taught himself to use the Blender modelling software. Becta's (2008) research indicated that boys tend to experiment and find out more about software, while girls prefer to use the software for a purpose.

Year 13 students had problems with transferring documents between LibreOffice and Microsoft Word as they lacked understanding of LibreOffice formatting and converting documents between the two platforms, thus suggesting a need for instruction in the use of LibreOffice (Reisinger, 2016). A male student rated LibreOffice very highly regarding features and ease of use once he had taken time to learn the software.

5.2.7 Web survey of Year 11–13 students' opinions

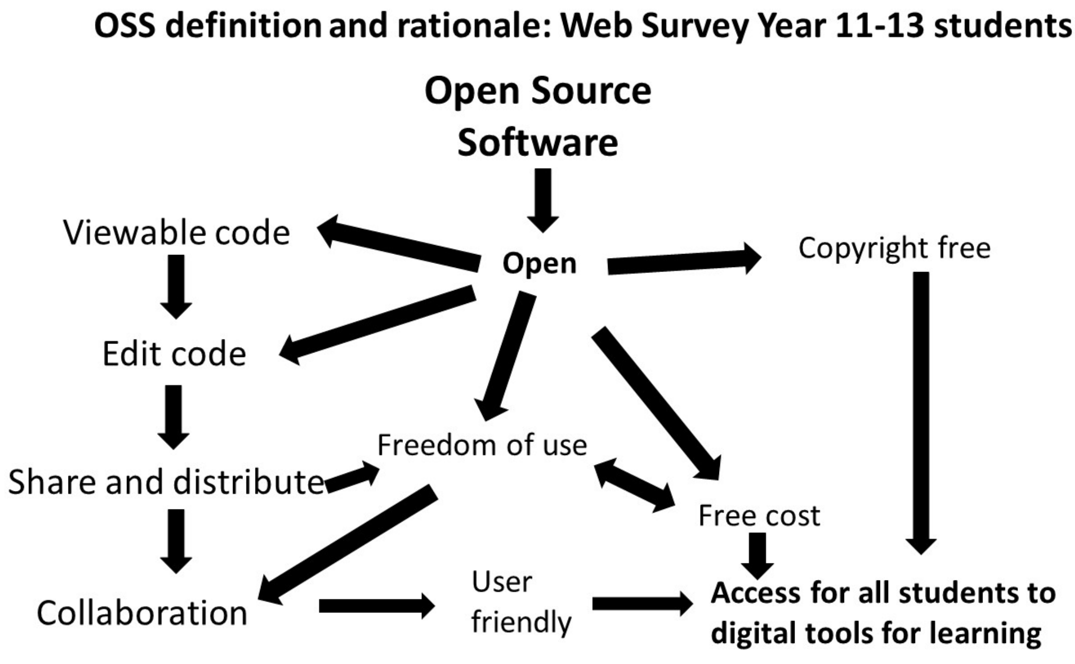

Figure 5.7 Web survey Year 11–13 students' definition and rationale for OSS (N= 93; See Section 4.2.6)

Figure 5.7 indicates that Year 11–13 students participating in the web survey had a good understanding of essential principles of OSS, including its free cost and access to a wider selection of software for their study. Students could access software to help with their studies without the barrier of cost for themselves and the school and install it on their own devices without copyright restrictions. Figure 4.12 indicates that a very high percentage of students brought a combination of mobile phones, laptops and tablets to school as personal mobile devices, with any specialist software for specific subjects (e.g. photo editing) installed on personal devices needing to be either OSS or proprietary software purchased by the student.

Software plagiarism can be a major problem with teenagers who download and install illegal proprietary software (Yeun, 2007). Year 13 focus-group students briefly mentioned the temptation for students to download proprietary software, but they were aware that this is illegal (Copyright Act, 1994). Wright (2013) cited the case of a New Zealand computer dealer who installed pirated copies of Microsoft Windows software on laptops and sold them on the Trademe website. Yeun (2007, p. 1) reported that, in the United States: "According to the Software and Information Industry Association (SIIA), one-quarter to one-third of all software used in K–12 schools in the U.S. is illegal." Kemp (2012, p. 2) recalls that, as a teacher, "several years ago I asked a classroom of students how many of them used pirated software at home; most of the hands (reluctantly) went up".

In New Zealand, the Ministry of Education software agreement ensures that all schools use legal copies of proprietary operating system and office software on their school networks (Ministry of Education, 2016). In 2015, Jackman (2015) informed schools that Microsoft has made access to the closed source cloud-based office software (Microsoft 365) free for students in New Zealand schools. Access to Google Docs software is also free through the Google Apps for Education account (Ministry of Education, 2019), but the Ministry software agreement does not extend to specialist proprietary software. Open source software that is available for student BYOD devices is a step that schools can take to combat piracy of proprietary software. Tong (2004) argues that educational institutions that cannot afford to pay licences might resort to installing multiple copies of proprietary software but, by using OSS, the number of copies required can be installed on the school network legally. Tong (2004), Reisinger (2016) and Laden (2010) stated that, if a school uses OSS, then students can use copies of the educational software and stay within the copyright law.

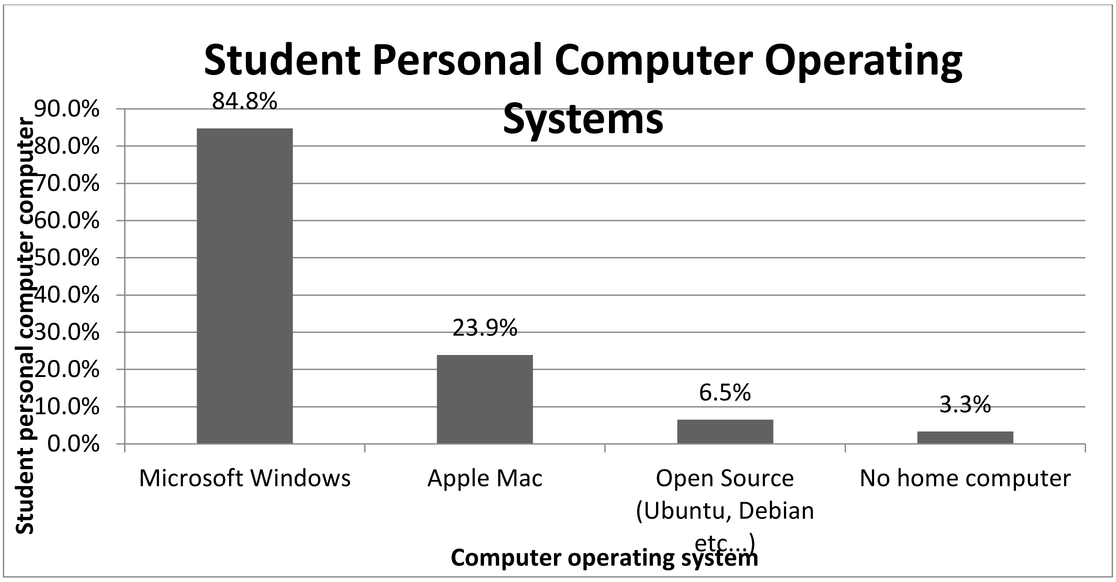

Figure 5.8 Percentages of students (Year 11–13) using different operating systems (N=93)

Figure 5.8 shows that 85% of the students surveyed have Microsoft Windows as their operating system on their personal computers, with a further 24% having Apple operating systems. OSS is installed on 7% of home computers and 3% of students indicated that there was no computer at home. Students who have either Microsoft or Apple operating systems run either proprietary software or OSS on their BYOD that they bring to school. Figure 5.8 shows that the majority of students use proprietary operating systems on their personal devices. OSS such as LibreOffice and the Gimp were available for both Microsoft and Apple computer operating systems for student laptops if required.

Students using school computers were using an OSS operating system with which they were not familiar, but focus-group interviews indicated that very little help and instruction were given to students on the use of the Edubuntu interface on the school computers. This might have contributed to some initial confusion among students in the operation of the school computer software. A year 11 student stated that it was a bit confusing to start with because of not really knowing how to use it. But, after learning to use Edubuntu through peer assistance, it became really useful.

Comments from the focus groups (Year 11–12) indicated that students need some tutorials on use of the software. Students were aware of the large amounts of software available on the school desktop computers, but no instructions were provided by the school in using it, either as web-based tutorials or just-in-time help. As part of the induction process into the school, professional development in OSS should be provided to year 11 students (Reisinger, 2016). Penn Manor High used student apprentices to mentor other students in the school on the use of OSS (Reisinger, 2016).

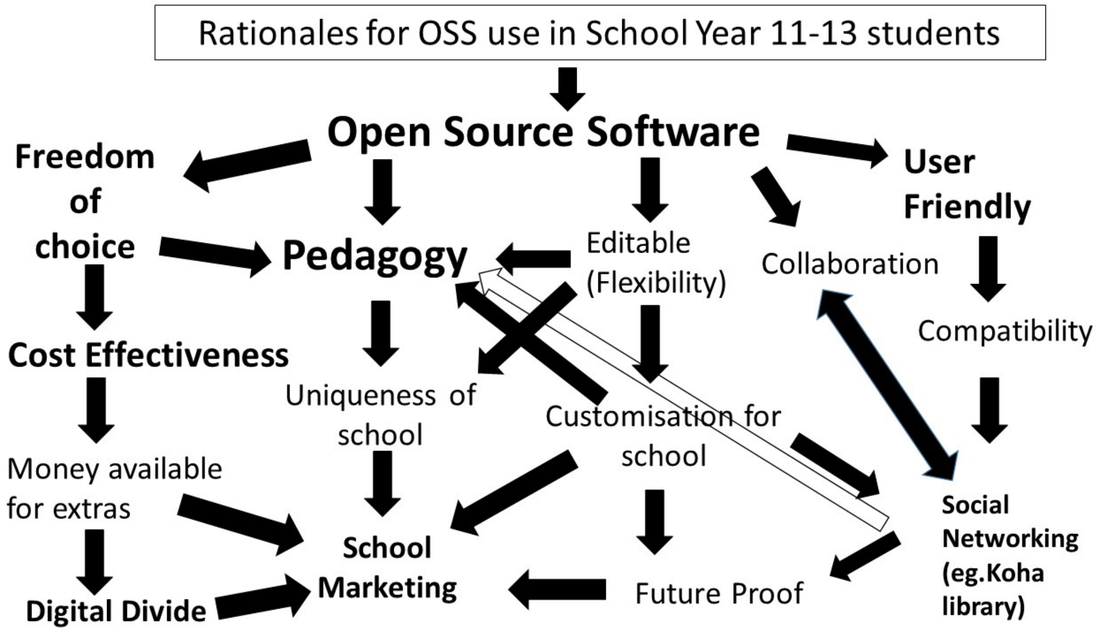

Figure 5.9 Year 11–13 students' rationales for open source software use

In the web-based survey, Year 11–13) students identified various reasons why the school uses OSS (Figure 5.9). Reasons included cost savings which allows funds to be spent elsewhere and the availability to support specialist subjects (Reisinger, 2016). Hart (2003) and Pfaffman (2008) suggested schools could take advantage of the cost savings to purchase more technology or provide more staff with professional development in the integration of technology. Pfaffman (2008) also argues that OSS gives schools the freedom to choose their own software and avoid forcing students to purchase proprietary software or be unwitting marketing agents for the software (see Figure 5.9). Availability of OSS overcomes the temptation to use pirated software on students' personal computers (Yeun, 2007).

Pfaffman (2008) and Reisinger (2016) identified a similarity between the development of OSS and the pedagogy of inquiry teaching (see Figure 5.9). OSS developers share software with the intention that their ideas and innovations spread throughout the community to benefit society. Reisinger (2016) states that students at

Penn Manor High have developed OSS for the benefit of their school, such as OSS to help to organise the annual Career Day, which is similar to the school notice board software written for the case-study school. Pfaffman (2008) noted the large number of amateur astronomers frequently discover new objects and share these freely with the astrological community as a similar example. In Thornburg's (2007, p. 9) research into OSS use in a Michigan high school, teachers reported: "They saw the classroom computers as tools that facilitated more self-directed learning". Moyle and Ruwoldt (2004, p. 12) suggested that staff development in the use of OSS is necessary because many students would be unfamiliar with it and that "whole school and small groups hands-on sessions would be useful".

Although students indicated that the use of OSS enhanced student learning, many studies are unclear about whether the use of computers in classrooms improves learning (Cuban, 2021; Cuban as cited in Pfaffman, 2008; Dynarski et al. as cited in Pfaffman, 2008; Pfaffman, 2008). Students perceived that ready access to OSS is an important justification for inclusion as part of the school's learning environment. Pfaffman (2008, p. 29) concluded: "It is reasonable to expect that large-scale measurable changes in how computers affect schools are yet to come. Getting enough computers into schools that they will become a regular part of every student's learning is a first step." Appalachia Regional Comprehensive Center (2013, para. 3) stated that "ample evidence from the last 10 years suggests that particular technologies can enhance student knowledge and skills". As evidenced by the high numbers of desktop computers available in the school and the high number of students bringing their own devices to school (Figure 4.11), technology is embedded within the school and this research has established that technology is a significant part of the students' learning process.

Focus groups reported positive views of the user friendliness of the OSS interface (Figure 5.9). Thornburg (2007), in his study of Michigan City High School which had recently introduced Linux-based computers, found that students were unaware that they had been using open source software and that teachers "felt that the only thing that mattered was that the computers were intuitively easy to use" (p. 8). Becta (2005b, p. 8), from a study of teachers using OSS in schools, reported that "in general the view appeared to be that these open source office applications were easier or simpler to use than the non-OSS equivalents".

Cost savings was mentioned as a rationale by all the stakeholders interviewed, including student web survey participants (Figure 5.9). Several studies have shown considerable cost savings for schools that run OSS, with Becta (2005b, p. 22) reporting "the total cost of ownership from the schools for an OSS secondary was £489.99 compared to a non-OSS secondary cost of £650.10. An annual savings of an OSS secondary per computer of £160.11." Doesburg (2009) reported that a senior high school is saving $200 000 by using OSS. Reisinger (2016) reported that, since Penn Manor district schools switched to OSS, savings amounted to $890 000. The cost savings and freedom to use OSS also narrow the digital divide in the school student community when all students have equal access to the software (Edwards-Hamilton & Williams-Young, 2011).

Students mentioned the school's uniqueness (Figure 5.9) as the only high school exclusively using OSS attracting publicity to enhance its reputation for being technologically-advanced. Doesburg (2009), a reporter for the New Zealand Herald, published a report about the school's uniqueness in its exclusive use of OSS.

5.2.8 Emergent themes in stakeholders' perceptions of definitions and rationales for OSS

Section 5.2.9 discusses emergent themes in the use of OSS in the senior high school based on stakeholder interviews reported in Section 4.3. The themes associated with using OSS in supporting learning in the case-study school and discussed in this section are likely to be useful for other schools considering using OSS for learning support.

5.2.8.1 Degree of ease/difficulty in using OSS

Students liked OSS because it was uncomplicated and contained only the essential features for learning tasks. Trappler (2009, p. 3) noted that open source software has "its origins in IT infrastructure (which has) given OSS the image of having poor user interfaces built by IT for IT". But this is changing as OSS product options expand to applications including Firefox, LibreOffice and Edubuntu Linux. Generally, comments regarding the usability of LibreOffice were positive within the focus groups. Negative comments were not about the interface, but about incompatibility with Microsoft Office. Wallen (2015, para. 6) noted that "one of the biggest steps forward with LibreOffice is the much-improved Microsoft import and export filters. This might be the first release where Word and Excel documents import flawlessly." Students liked the menu bar and ease of access to Libre writer functions. As open source software matures, the interface gets more user friendly as more developers have input to the software. The development of the Firefox browser is an example, with Paul (2015) and Gokey (2014) stating that, because Firefox is open source, it is very customisable and safe with a user-friendly interface that has developed over time.

Edubuntu is the Linux operating system that is installed on the case-study school's network and desktop computers. Edubuntu (n.d., para. 3) states: "Our aim is to put together a system that contains all the best free software available in education and make it easy to install and maintain." Edubuntu (n.d., para. 5) stated that one of its objectives is to "provide a highly usable interface for both students and teachers". Students commented there was a learning curve in getting used to the interface and operating system but that, after a while, students got used to them and had no problems.

5.2.8.2 Cost saving and freedom of use

Open Source Initiative (2007) states: "The license shall not restrict any party from selling or giving away the software as a component of an aggregate software distribution containing programs from several different sources. The license shall not require a royalty or other fee for such sale" (para. 1). Because the OSS was free to use both in terms of cost and freedom of access, OSS has many benefits for the school and its stakeholders:

1. Cost savings for the purchase of specialist software.
2. Risk-free trialling of new software.
3. Large catalogue of software being available on the school desktops for student use.
4. Students being able to install the software on their own home desktops, laptops, tablets and smart phones if the OSS is available on multiple platforms (e.g. LibreOffice).
5. Money being saved being spent elsewhere in the school.
6. School not locked into using a particular software vendor.

5.2.8.3 *Home and school access to open source software*

Students and teachers at the school have freedom to access and install the OSS on devices which can be used at school or home. Edwards-Hamilton and Williams-Young (2011) discuss how schools provide students with access to the same software that is used in the schools with no cost to the students:

1. Teachers and students can become familiar with and use the same software at school and at home.
2. Students can complete work at home using the same software.
3. Use of OSS at home can help to bridge the digital divide because students do not have to spend money on proprietary software.
4. All students regardless of family income have access to software.

5.2.8.4 *Open source software support for learning*

The case-study school used open source software to support learning for both teachers and students. OSS can support learning in the following ways (Reisinger, 2016):

1. A large variety of software is available to support specialist subjects.
2. Because everyone in the school is using the same software, students can support their peers.
3. A large number of help files are available on the internet to support the use of open source software.
4. Educational open source software is available on school desktop computers.
5. Open source software is regularly updated and students have access to the latest versions.
6. Teachers' school laptops have an OSS operating system and OSS software installed for teaching purposes.
7. Open source software such as LibreOffice complement cloud-based software Google Apps for Education.

5.2.8.5 *Availability of open source software*

Open source software is available at no cost to support the learning of all students at the school, which has the choice to select and install suitable software to support learning or to supplement the cloud-based Google applications for Education used on student portable devices:

1. A large range of OSS is available on all the school computers to support all subject areas.
2. Students who do not own their own computers have ready access to the same software as everyone else at school.
3. OSS runs on low specification computers.
4. OSS such as Mahara and Moodle run in the browser with no software installation necessary.
5. The use of Google Docs enables students to access documents whether using the school Linux desktops or their own personal laptop, tablet or phone.

5.2.8.6 Which OSS was preferred by students?

The Gimp and LibreOffice were the software most liked by students (Figure 4.20). The GIMP (GNU Image Manipulation Program) is a popular OSS image-manipulation program (especially for photo-editing and image creation) that is available for all main operating systems. The GIMP has been in continuous development for 20 years (GIMP, n.d.) and is a creative open-ended program which suits the needs of media studies and technology students. At the senior high school, the GIMP is used as the equivalent for Photoshop. There are many extensive tutorials available on the internet for the GIMP and the school has also employed an outside consultant to assist teachers in the use of the GIMP.

LibreOffice is the open source office program that is used extensively throughout the senior high school and is available for Windows and Apple operating systems. Whittum (2013) describes LibreOffice as “a productivity suite that very much resembles Microsoft Office prior to the graphical interface update initiated in Microsoft 2003. The user has access to menus directly, not tabs, which long-time Microsoft users will like.” Some students in the focus groups liked LibreOffice because of the simplicity of its interface. LibreOffice contains a word processor, spreadsheet, slideshow presenter, database and drawing software. The latest versions of LibreOffice and Microsoft Office 2016 reduce compatibility problems between users of the office software (Wallen, 2015) that were the major issue identified by students when creating a word processing document at school using LibreOffice and emailing it home to continue working in Microsoft Word. Most students started using Google Docs to eliminate compatibility problems, even though this reduced their formatting capability. Google Docs allowed seamless connection to the documents from any location and documents are automatically saved in the cloud.

Although Google Docs is closed source cloud-based software, it is widely interpreted as being open source within the school. The Google Docs app is available for smart phones and tablets for both Apple and Android operating systems and the senior high school has a Google Apps for Education account. All students have their own Google account for access to Google Docs and a school Gmail address. Google Docs has a word processor, spreadsheet and forms application. Focus-group data and the teacher interviews indicated that Google Docs was widely used by both teachers and students for learning purposes.

Audacity is an open source audio editor that was available on the school network. According to Audacity (n.d.): "Audacity is a free, easy-to-use, multi-track audio editor and recorder for Windows, Mac OS X, GNU/Linux and other operating systems." Audacity is an example of an open source program that is available for multiple operating systems to enable student use on home computers for continuing work begun at school. It is a powerful audio editor that has been under development by the open source community for 15 years and is popular with educational users (Wikipedia, 2021b). Audacity was used by students and teachers throughout the school for audio editing purposes.

Inkscape is a drawing program available on the school desktop computers Inkscape (n.d., para. 1) that "offers a rich set of features and is widely used for both artistic and technical illustrations such as cartoons, clip art, logos, typography, diagramming and flowcharting". Used in the Media Arts department along with GIMP and Blender. Inkscape was also available in Windows and Apple operating systems.

Students' identification of their favourite OSS reflects the philosophy behind the use of software within the school. All the software chosen are creative and enable students to create knowledge and apply their learning to authentic tasks. This is linked to the eLearning vision (Albany Senior High School, n.d.-c, para. 1): "Our vision for technology at ASHS centres around the role it can play to achieve our vision: to nurture, inspire and empower students to achieve highly and become good citizens." This role of the software is discussed later in Section 5.4.

Stakeholders also discussed the negative perceptions about OSS when giving opinions on the school rationales for use in education. Section 5.3.1 discusses barriers for inclusion of OSS in schools.

5.2.8.7 Complexity of open source software

In contrast to what the students like about OSS (namely, ease of use), 25 students in the web survey indicated that it was too complicated. Focus-group feedback from all year levels, particularly from female students, indicated that a lack of support available on the use and operation of the OSS. Chalmers and Osborne (2014) list over 40 open source programs available on the case-study school's desktop computers. During focus-group interviews, the ePortfolio software Mahara was specifically mentioned as being difficult to navigate and use by the students for reflecting, sharing and planning their learning. Students used Mahara when planning and evaluating their projects.

The Year 11 focus-group discussions identified a need for induction into the use of OSS in the school. Reisinger (2016) introduced a student-led technology support program in which students became OSS apprentices who assist other students in the operation and use of OSS at Penn Manor High School. Reisinger (2016) also discussed how OSS student apprentices authored OSS software to assist with the school network and school management. Focus group students indicated that help with OSS was received from their peers in a just-in-time manner.

5.2.8.8 Compatibility issues between LibreOffice and Microsoft Office

Lack of compatibility between LibreOffice and Microsoft Office editing files was a major issue for students who had problems with formatting when they started a document at school and emailed it to their home. When the document was opened in Microsoft Office, formatting styles were lost. Some students had difficulty opening the document if it was saved in the ODF (open document format) native to LibreOffice. In both focus-group interviews and the web survey, students reported their frustration with compatibility, with some students reporting that they use Google Docs because of the difficulties with file compatibility.

The ability for students to edit documents between school and home is important. Chase (2010, p. 6), in her study of digital technology in and out of school reported that "students were found to be high users of technology outside-of-school for entertainment, communication and productive purposes". Chase was most surprised that students used ICT extensively for producing knowledge and found that the "high users of technology outside the school were more likely to be engaged and to participate in school" (Chase, 2010, p. 5).

5.2.8.9 Limitations of open source software

There is a perception that, because OSS is 'free', it must be limited in the features available and the number of software programs available (Feller, Fitzgerald, Hissam & Lakahani, 2005). In reality, there are many thousands of open source software programs available which are stored in file repositories on the internet (Datamation, 2015). Deshpande and Riehle (2008) studied 5000 active open source projects and found that the code base of the software and the total number of OSS is growing at an exponential rate. Wikipedia (2021c) reports that SourceForge, an open source project hosting service, has 430,000 projects registered with 3,7000,000 users registered.

OSS is developed by groups of programmers who are not necessarily designing the interface for a broad spread of users. Optimus Information Inc (2015) stated: "Open source projects are complex packages of software that are not as closely aimed at markets of unskilled users as is much proprietary software" (p. 5). "Desktop Linux has barely penetrated the PC market where alternate, easy to use products already exist that do not have to compete based on high performance metrics" (Optimus Information Inc, 2015, p. 5).

Comparisons of office software such as LibreOffice and Microsoft Office have identified very little difference between the two regarding features (Kavanagh, 2004; Wallen, 2015). The GIMP and Photoshop have also been compared to reveal very little difference in their features (Czajka, 2013). The school deals with software requests on a case-by-case basis with the Deputy Principal One stating that, if no equivalent open source software is available, then proprietary software is purchased for use within the school. This is the case with the suite of Mac computers running the video software Final Cut Pro.

5.3 Advantages and Disadvantages of Open source Software in Education

Section 5.3 focuses on the third subsidiary research question concerning advantages and disadvantages of the use of open source software for teaching and learning at the senior high school. In particular, this section identifies themes based on opinions expressed by stakeholders during interviews and web surveys reported in Section 4.4.

5.3.1 Advantages of open source software in educational context

Senior Management (N=5), teachers (N=10), focus-group students (N=30) and school students (N=93) in the case-study school were surveyed through interviews, focus groups and web surveys about what they considered to be advantages and disadvantages when using OSS in the school for teaching and learning. Based on results reported in Section 4.4, themes were identified and are discussed in Section 5.3.1.1 to 5.3.2.8.

5.3.1.1 Open education philosophy

Senior Management reported during interviews (Section 4.4.1) that OSS was a good fit to the open educational philosophy of the school because all students were given open access to software that supported their learning. Teacher interviews (Section 4.4.3) also supported the open education philosophy that removes barriers to access to educational software.

Open source software (Redhat, n.d.) supports open education (Wiley, n.d.) by giving students freedom to use it for learning and supports open education tenets (State University, n.d.):

- Student passion for inquiry (OSS support for Impact Projects, school vision)
- Self-directed learning (Mahara ePortfolios and Impact Projects)
- Holistic education (online and face to face combination)

- Reciprocal relationship between school and home (Impact Projects, ePortfolio, Google Apps for Education and BYOD)
- School as an environment for personal choice (OSS, Moodle LMS, social networks, Google Apps for Education, Impact Projects)
- Learning by doing (OSS, school vision, Impact Projects, connectivism on the internet)
- Teachers as facilitators (learning commons teaching, social network support, Moodle LMS, Google Apps for Education).

The use of OSS fits the school vision of nurturing, inspiring and empowering students to achieve highly and become good citizens (Albany Senior High School, n.d.-a), removes barriers to learning, and gives all students an equal opportunity for learning. Implicit in open education (Wiley, n.d.) is choice and OSS gives students a risk-free choice of digital tools to scaffold their learning and support their thinking and learning. OSS supports the school's commitment to open education and student centred-learning in which students are actively involved with their learning (Albany Senior High School, 2011a).

5.3.1.2 Sustainability

The IT technician (Section 4.4.2) discussed the ability of the school to modify the code of software to suit its needs and cited the example of Koha Library software modifications. Students had also coded open source software to provide digital signage throughout the school.

The procurement of OSS under the open source licence enables the school to use, copy, modify and redistribute the code or content (Kaur, 2015). Because the school is independent, it is able to choose software to suit educational needs, distribute software to students, modify it to suit the school, and share improvements with the OSS community. Because there is no reliance on agreements with proprietary software firms, software use is sustainable in that the school can take advantage of regular updates at no cost.

Evidence of the sustainability of open source software includes the school's modification of Koha OSS by adding a rating system to books, or students' Impact

Projects involving writing the school's digital signage to enable news from a Moodle course to be displayed on flat screen-televisions throughout the school. Software has also been written by students to create OurTube, the school's localised version of YouTube to provide access to school-related videos via the school intranet. I observed students writing code for an alarm detector and a video game movie project using OSS during an Impact Project session. Students are knowledge as creators rather than knowledge consumers (Fullan & Langworthy, 2014).

Open source software is also being constantly upgraded and its 'bugs' are fixed by the developer community (Miller, 2011). The cost of upgrading to the latest version is free for the school. The IT technician also reported that open source community online forums were used to solve network or OSS problems.

Open School Solutions (2017) lists a variety of OSS which is available for students to support their thinking processes with no obligation on the school regarding the software to be used. A large variety of OSS is available on school desktops to support student learning, which can be added to as required by teachers or students. OSS can be customised by the school to give students a more-effective digital tool that can be used to enhance their learning in the school.

5.3.1.2 Accessibility

All stakeholders identified the accessibility of OSS as a major advantage. The principal discussed how graphics teachers used GIMP software as an alternative to Photoshop (Section 4.4.1.1) because it is downloadable via the internet and is available in both Linux-based and proprietary operating systems. Students have the option to install commonly-used software such as GIMP or Libre Office on Microsoft or Apple laptops. Teachers can teach in the school using the software and develop teaching resources around the OSS. There is a large number of support guides for the software available from sites such as YouTube. Students can also recommend that specific OSS be made available on the school network if it is required for their studies at school.

Sites such as OSAlt.com (https://www.osalt.com) provide suggestions for OSS as replacements for proprietary software. All commonly-used proprietary software has an open source alternative that can be downloaded with an open source licence. Craft (n.d.) suggests that schools use mature open source programs which have a stable interface rather than the latest release.

Because OSS is easily accessible, schools are not locked into using specific software and flexibility is built into the use. There is a huge range of OSS from which to choose to support a specific study strategy. The case-study school may install a range of OSS on school computers at no financial risk. The availability of OSS availability also deters students from using pirated software on their BYOD devices because the required software is freely available.

5.3.1.3 Bridging the digital divide

A common theme among all stakeholders, particularly senior management, was equal access to educational software for all students at the school (Section 4.4.1). Senior managers argued that, with OSS, no students were missing out on software to support their learning irrespective of family income or circumstances. Edwards-Hamilton and Williams-Young (2011, para. 4) define the digital divide as "the gap which exists between those who have access to information communication technology and those who do not have access". All students are able to use school desktop computers or to download and use OSS on either their BYOD devices or home computers for school assignments. For schools in low-income areas, this would be an even greater advantage. Hart (as cited in Sharp and Huett, 2006, p. 3) stated that "open source does a lot to bridge this gap". The case-study school is located in a high-income area and results from the web survey and focus groups indicate that the majority of students bring either a personal laptop and/or a smartphone or tablet to school regularly as a BYOD.

OSS is used in many countries throughout the world to reduce costs and give students from low-income families access to software (Dravis, 2003; Karume, 2012; Klein, 2008; Krishnaswamy and Marinova, 2012; Tomazin and Gradisar, 2005). Often the emphasis is just on providing hardware and software with little teacher professional development on integrating ICT (Krishnaswamy & Marinova, 2012). The one-laptop-per-child scheme is designed to give students in developing countries access to low-cost laptops with a Linux operating system and basic educational software installed (Negroponte n.d.).

5.3.1.4 Stakeholder support in the school

OSS was introduced at the case-study school at its inception (Section 4.2.3) to make it unique and known as technically-advanced (Section 4.35). My research has shown support from the majority of stakeholders in the school for the use of OSS, which is embedded into the school culture. For OSS to be successful, support from stakeholders is vital.

Student feedback in focus groups indicated that younger students would benefit from basic instruction in the use of the Edubuntu operating system and productivity software such as LibreOffice. A key part of Penn Manor High School's successful use of OSS is the involvement of students with the integration of open source laptops and a student helpdesk (Reisinger, 2016). Nesbit (2014) reported that 3500 Linux laptops have been distributed to students in the Penn Manor district. Students work alongside IT technicians in gaining valuable work experience in the maintenance of hardware and the provision of tutorials for students in the use of OSS (Reisinger, 2016). Student involvement would improve students' understanding of OSS and they could be mentors throughout the school. Student familiarity with OSS would also fit with the school's vision of building relationships with and supporting students (Albany Senior High School, n.d.-a).

The Penn Manor High model (Reisinger, 2016) would fit in with the Impact Project model at the case-study school. Pearce (2012) argues that OSS can be used to ensure a sustainable future by enabling shared development of OSS that can support the local environment and community development. Examples of this are seen in the Impact Projects (Kindley, 2013) created by the senior high school students.

5.3.1.5 Pedagogy

The role of technology in the school is to support and enable learning (Fullan & Langworthy, 2013), with the school senior management and teachers having a central role in defining the pedagogy used for learning. Figure 5.10 illustrates how pedagogy dominates the way in which students learn within the school using digital tools. Social constructivism, connectivism and the resulting communities of practice are embedded within the school, with constructive pedagogies being enabled by the technology available. The pedagogy differs depending on whether the students are working in the student commons, networking on the class Facebook page, collaborating on a Google Doc or reflecting in their ePortfolio; the pedagogy used is contextual. Many students have BYOD devices that are always connected to the Wi-Fi whether at school or home to enable contact with their learning networks and collaborators at any time or location. Figure 5.10 also illustrates that students use a combination of OSS, proprietary software and increasingly important cloud software as thinking tools for their learning. In this thesis, the mix of software/apps used by the students for learning is labelled a 'mixture'. Smart telephones, tablets and laptops are becoming increasingly important as students connect with others through cloud computing and social networks (Siemens, 2005).

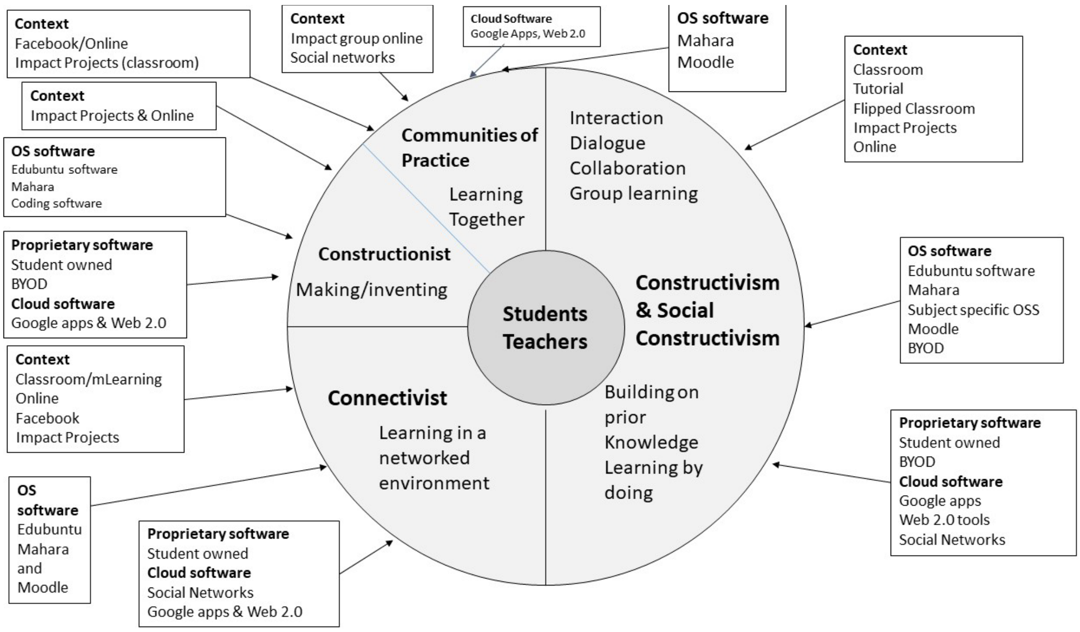

Figure 5.10 Learning theories and software used in the senior high school

ICTs are used in social constructivist and connectivist learning environments to produce rather than replicate knowledge. Table 5.2 demonstrates how pedagogies enabled by ICTs in Figure 5.10 lead to the collaborative learning practices and student-directed inquiry learning which were integral to student Impact Projects (Section 4.5.4.2). ICTs are used as thinking tools to enable learners to think critically, collaborate, communicate and analyse information to solve problems and to create artefacts (Fullan & Langworthy, 2014). OSS and cloud-based software are a better fit with the pedagogies of social constructivism and connectivism that involve learners in constructing knowledge and solving problems together in small teams via networks. All team members have ready access to the technologies needed to work together, with learning and knowledge being stored and shared from the network (Siemens, 2005).

Table 5.2 *Comparison of traditional pedagogy and emerging ICT-enabled pedagogies*

Traditional pedagogy	Emerging pedagogy enabled by ICTs
Instructivism	Social constructivism, connectivism
Activities prescribed by the teacher	Activities determined by learners
Individual	Working in teams
Apply solutions to known problems	Find solutions to new problems
Teacher directed	Student directed
Summative	Diagnostic
ICTs as a tool	ICTs as a thinking tool

Source: Adapted from Tinio (n.d.) (as cited in Munienge & Muhandji, n.d., p. 3)

Fullan and Langworthy (2014, p. i) enlighten educationists to the possibilities of deep learning when "new pedagogies require students to create knowledge and connect it to the world by the power of digital tools". The combination of digital tools from OSS, cloud-based closed software, social networking apps (Fullan, 2015) and BYOD proprietary software in the Impact Project programme enables students (groups and individuals) to solve problems, collaborate, create knowledge, create artefacts and share their knowledge at a deep level not possible in the traditional school. Deep learning pedagogy is the key to developing learners who will use digital tools to contribute positively to future society (Fullan & Langworthy, 2014).

5.3.1.6 Cost saving

Cost saving for the school was mentioned by all the stakeholders. Craft (2011, p. 1) states: "Open source software can provide a viable alternative to traditional software at a fraction of the cost." Apart from the Windows and Mac operating systems and office software which are provided via a Ministry of Education (2014) software agreement, all other specialist software must be purchased by New Zealand schools. Considerable savings are associated with the school not having to purchase specialist software such as Photoshop. Installing open source alternatives such as the GIMP on school computers enables cost savings, as does students not being compelled to purchase specialist proprietary software for their BYOD devices and home computers.

5.3.1.7 Security and virus protection

The IT technician reported that the school did not run any anti-virus software over the network because any executable files would not run on the Linux network. Although the open source code is open, there is potential for hackers to exploit vulnerabilities although, in reality, hackers tend to hack commonly-used software for maximum impact as stated by Adams (2010) and Trappler (2009). Allcock, Chen, Killen and Simpson (n.d.) argue that, because the source code is open, security is enhanced because any threats/flaws are able to be identified and fixed by the OSS community. Transparency enhances open source security (Optimus Information Inc., 2015) as does its larger user base (Pankaja & Mukund, 2013). Security and virus protection are advantages for the implementation of open source software in education because they free up network resources and technician time and enable a more open and stable WiFi network, which is necessary in the school because students and teachers depend on internet access for learning.

5.3.1.8 Ethics

Open source software is developed by the community for the community (Erfanian, 2013). Meyer (2000) identified reasons for producing OSS as the desire for good and to help people by producing software tools. Participating as a collaborator, desire to learn, marketability and the search for glory are motivations for becoming an OSS programmer (Meyer, 2000). Some people do not want to support large software monopolies, both commercial and free software have their place, and people are encouraged to "strive to combine the best of what the two communities have to offer" (Meyer, 2000, p. 20).

Stakeholders also expressed opinions about the freedom from monopolies and the democratic choice offered by open source software.

> *You are not bound by the big boys, Mac, Windows.*

> *We don't know what our students are going to need in the future. So who's to say Apple is the best or the Windows suite is best for one student; it's free so people can access it.*
>
> *It stops the restriction on people on limited budgets from being able to participate in photography and design, and these things where the programs usually cost a lot of money.*
>
> *It seems to me a perfectly functional, accessible and democratised open source software way of gaining those tools so to speak.*

Open source software being freely accessible for everyone in society is an example of utilitarianism. "Its basic principle is that everyone should behave in such a way to bring about the greatest happiness of the greatest number or people" (Forester & Morrison, 1994, p. 15). All stakeholders at the school have the freedom to select/access and use OSS on school or personal computers as an alternative to commercial software.

Deontologists argue that the provision of OSS for education is morally right. Forester and Morrison (1994, p.16) argue that deontology or Kantianism "stresses the intrinsic character of an act and disregards motives or consequences". OSS also follows Kant's first categorical imperative for the following reasons (adapted from Hoffman, Frederick & Schwartz, 2001 p. 30):

1. Open source software is free to access.
2. Open source software makes no reference to charging for the software.
3. Coders make it available to the public because of a desire to improve society.
4. The point of difference with open source is freedom.

Stakeholders, more particularly the BOT, senior management and teachers, agreed with the freedom of students to access OSS for their learning. Society benefits as a whole in having the freedom to access the digital tools in open source software.

The case-study school aimed to free itself from the monopolies and market domination of software (Doesburg, 2009). Foster, McChesney and Jonna (2011) define a monopoly as "firms with sufficient market power to influence the price, output, and investment of an industry—thus exercising 'monopoly power'—and to limit new competitors entering the industry, even if there are high profits." School stakeholders argued that students were empowered by the choice not to use the proprietary software of a dominant company which also imposes its own file formatting standards and therefore reduces the ability to share and collaborate with others (Doesburg, 2009). The school had not signed up to the Microsoft agreement with the Ministry of Education (2015). The school operated in a democratic manner in that students were given the choice of using the school OSS, cloud-based software or their own proprietary software on their laptops.

5.3.2 Disadvantages of open source software use in senior high school

Section 5.3.2 focuses on the perceived disadvantages of the use of OSS in the senior high school by highlighting themes that emerged from stakeholder interviews and surveys.

5.3.2.1 File compatibility with proprietary office software

Students and teachers reported problems with file incompatibility between documents created in Microsoft Office and then opened in LibreOffice or vice versa. Issues reported included loss of formatting, images and fonts, which resulted in a change in the document. Students also became frustrated with documents failing to open. Experienced users explained solutions, but students perceived that little help or tuition was given in the use of LibreOffice. The focus groups reported increased use of Google Docs become documents were easily accessible from both school and home with no saving necessary. Google Docs provided the basic tools for editing documents and saving them to the Microsoft Office or OpenDocument format, which can be edited in LibreOffice.

Ask Ubuntu forums (Askubuntu, n.d.-b) provided solutions for ensuring compatibility between documents created in LibreOffice, including ticking compatibility options in LibreOffice, using basic tables, saving in doc, or RTF or PDF format, and other tips for a smoother transition between the two office softwares. Students had the option of downloading LibreOffice to their laptops or their home computers to ensure compatibility. Student feedback from the focus group indicated that peer or online help about Libre Office would be useful.

As both Microsoft Office and LibreOffice evolve, file incompatibility will become less of an issue; as it stands, both office suites support the doc, RTF, ODT and other commonly-used document formats. Wallen (2015, para. 4) notes “LibreOffice Writer is vastly superior to Microsoft Word for what I need. Not only does it hold true to file format standards, but it doesn't add extraneous hidden data to trip up the tool I use to convert files into .mobi or .epub. LibreOffice creates cleaner files... period”.

5.3.2.2 Lack of open source software for specialist hardware applications

The workshop-based technology teacher expressed frustration that, when he used PLCs (Picaxe) with his classes, he had problems with a lack of Linux-based drivers and interfaces for programming the PLC. However, he had solutions including bringing in his personal PC laptop for programming the PLCs. He also had problems running OSS 3D software for creating wood joints.

A solution for the teacher (Gerard, 2018) would have been to have a small COW (computer on wheels) with some PC laptops with appropriate Windows software for use when using the PLCs in his classes. Another alternative solution would be to use Linux-compatible PLCs such as Arduino (n.d.) or Raspberry Pi (n.d.) hardware.

Another alternative again would be to explore the use of the OpenPLC which has been developed as the first open source PLC (Alves, n.d.). The OpenPLC would not only give students experience in programming using a Linux interface, but also the opportunity to participate and contribute to the open source community. Irrespective of the operating system being used, students were involved in using digital tools in the deep thinking processes and creating knowledge (Fullan & Langworthy, 2014).

5.3.2.3 Development of interface/usability compared with industry standard proprietary software

Some students and teachers reported that the open source software interface was neither well developed nor user friendly. Optimus Information Inc. (2015, p. 5) stated: “Open source projects are not as closely aimed at markets of unskilled end users as much as proprietary software.” Hence a technical rather than a user-friendly interface has been developed for some OSS. Students and teachers mentioned frequently that the number of steps involved in completing a task using OSS was high compared with proprietary software. Nichols and Twidale (2003, para.78) comment that "engaging typical users into the development process OSS projects can create a networked development community that can do for usability what it has already done for functionality and reliability". Raza, Capretz and Ahmed (2010) report that, in the study of improvement of OSS usability, developers needed to take into consideration user requirements, incremental design approach and usability testing in the design of OSS.

Teachers reported that they had employed an expert to give professional development on the GIMP image editor and to create resources for students using the software. YouTube tutorials were also used to scaffold learning for students on the GIMP interface.

5.3.2.4 Debate about industry standard proprietary software vs. OSS for use in industry

The information technology teacher and some visual arts teachers expressed concerns that students were using open source productivity software rather than the industry standard proprietary software, such as Photoshop and Autodesk CAD, that they would use in their career in industry.

Singh, Bansal and Jha (2015) identified advantages of using industry standard proprietary software in schools as being: its use in industry; its user-friendly interface; availability of specific help from retailers or software companies; the mindset that it is superior; the free licence; the generic IT skills used; its similar output; not being locked into a single vendor; and availability of a community of practice for sharing outputs and ideas.

After weighing up the pros and cons of using proprietary software for teaching and learning, there is no clear-cut answer. The issue of whether to replace OSS with proprietary software must be addressed on a case-by-case basis. Schools need to take account of individual circumstances and whether OSS serves the best interests of students in achieving learning goals. In the case-study school, a small suite of Mac computers with Final Cut Pro proprietary software were installed because of the lack of high quality equivalent open source software.

5.3.2.5 *Reliability and stability issues with OSS*

Reliability is often an issue that is brought up regarding OSS. Regarding reliability, Pandey and Tiwari (2011) found that OSS was equally or more reliable than proprietary software. QINETIQ2001 cited in GB Direct (n.d.) stated that "much open source software becomes highly robust at a surprisingly early stage of its development, and mature open source products are setting new industry standards for bullet-proofness". There were no issues with the reliability of OSS, with stakeholders reporting that OSS was stable on the school's network.

5.3.2.6 *Lack of teaching resources to support open source software*

Because the case-study school is the only school in New Zealand to use OSS exclusively on school desktop computers, there are no schools with which to share teaching support resources. New teachers must become familiar with the specific OSS and produce their own teaching resources. Some teachers reported arriving at the school with many resources involving proprietary software which had to be converted to OSS. However, the teachers were aware that the school exclusively used OSS when they applied to join the school.

YouTube has many short video tutorials on OSS. Teachers and students also have the option of producing their own video tutorials and uploading them to either YouTube or OurTube (the school's private video channel). OSS community of practice has also produced help resources, such as the GIMP website https://www.gimp.org/ which has tutorials and help documents available (GIMP, 2016).

There are also other websites that make available support materials on the use of the GIMP in education (Petty, 2012). The senior high school can build up its own OSS teaching resources to share via Moodle, websites or social networking sites.

5.3.2.7 *Network printing issues*

Both students and teachers reported problems when printing PDFs caused by a school networking problem with printer drivers or the network structure (Askubuntu, n.d.-a). Because the ability to print reliably over the school network is essential for both teachers and students, considerable stress was reported by students who needed examples of their school work printed for NCEA (National Certificate in Educational Achievement) assessment.

5.3.2.8 Time to adjust to open source software

Teachers mentioned the large amount of time taken to adjust to using OSS when they first joined the school. Also, Year 11 students mentioned the time it took them to adjust to the new operating system and programs loaded onto school desktop computers.

Teachers would benefit from a community of practice (Bradley & Fogelsong, 2021) in which experiences could be shared and a school Moodle site for collaborating and sharing. This would build a bank of resources for existing and new teachers and help guides could be edited and shared. Mentors could also be appointed to help new staff members with the of the new operating system and specialist programs. A student apprentice scheme (Reisinger, 2016) was set up at Penn Manor High School to support the open source devices and OSS for students and teachers.

Focus-group students reported the need for an induction programme to show new students how to access computers and OSS operating system where software resources are. The ePortfolio Mahara interface was confusing and needed to be explained to students before they could set up their ePortfolio, start reflecting and share their reflections. Reisinger (2016) involved students in the maintenance of OSS computers at Penn Manor School and set up a successful help desk.

5.4 Pedagogy Used in Classrooms in Relation to Open Source Software

Section 5.4 discusses the pedagogy in classrooms when using OSS. The school vision is that "we nurture each other, we inspire each other, we empower each other to achieve highly and be good citizens" (Albany Senior High School, 2020, n.d.-i. 1). Stakeholders' opinions relate to the use of OSS to support the school vision for learning. Senior management, the IT technician, teachers and students were surveyed about their opinions about the use of OSS to support learning in the school. Senior management, teachers and the IT technician participated in individual interviews whose results were reported in Sections 4.5.1, 4.5.2 and 4.5.3. Ten students each from Year 11, 12 and 13 were interviewed in focus groups (Section 4.5.4) and 93 students were web surveyed (Section 4.5.5).

5.4.1 Learning theories underpinning pedagogy used in classrooms in relation to OSS

Pedagogy is commonly defined as the science of teaching and includes "the thinking and practice of those educators who look to accompany learners; care for and about them; and bring learning into life. Teaching is just one aspect of their practice" (Smith, 2012, para. 1). The role of the senior high school is preparing students for lifelong learning, working in society and further education (Mattila & Miettuen, (n.d)). Robinson (2009) discussed the speed of change in society and how students must be prepared for fast-changing world driven by changes in technology. Wagner (2011) argued that schools need to prepare students for working in the global knowledge economy using new skills that are not taught in today's schools. Teachers need to change their pedagogy for students to acquire digital literacy skills in an authentic student-centred way (Gilbert, 2006). Fullan (2015, p. 162) argued that students need to "pursue social learning through exploration and engagement" in a social constructivist learning environment. West (2018, p. 598) states that "technology has the potential to accelerate, amplify and expand the impact of powerful principles of learning".

The school's vision statement embodies the aim of the school in preparing students for living in society (Albany Senior High School, n.d.-a):

- *"Students learn best when they feel valued and are actively engaged in their learning. Warm, positive relationships between teachers and students are essential for learners to thrive;*
- *Young adults learn best when they:*
    - *Know what they are learning and why,*
    - *Connect their learning to real life situations,*
    - *Have multiple opportunities to build on existing knowledge,*
    - *Examine and use new knowledge and*
    - *Have time to reflect on their learning."*

The school's teaching areas comprise open learning commons where up to four classes share corners of a teaching space. The 100-minute teaching periods allow concepts can be covered in depth. Tutorials are held throughout the week with the home teacher who mentors mixed-level student groups and provides pastoral care.

Student focus-group feedback revealed that student learning was supported by teachers both in tutorial groups and online networks.

Teachers reported scaffolding student learning using a mixture of technology including Open source software, Google for Education, Moodle, Facebook groups, Twitter, Edmodo and Mahara ePortfolio. Student–teacher relationships were scaffolded online using social networking and cloud-based software in a connectivist learning environment (Siemens, 2005; West, 2018).

5.4.1.1 Learning theory

Learning is defined as “the gaining of a specific achievement, or end state” (Hirst, 1971, cited in Lee and Ward, 2013, p. 44) and is achieved when there is a change in the person, knowledge or skills. Waters (2011, cited in Wheeler, 2015) outlined the characteristics of the new learners for the 21st Century:

- *Self-directed*
- *Better equipped to capture information*
- *More reliant on feedback from peers*
- *More inclined to collaborate and*
- *More orientated to being their own nodes of production.*

Learning theories are discussed below in the context of students having access to BYOD and mobile telephones and being connected to the school Wi-Fi network during their school day. Learning theories discussed in this chapter (constructivism, social constructivism, constructionism, connectivism, inquiry) relate to the integration of technology for learning in the case-study school.

5.4.1.2 Constructivism

Students learn by constructing their own learning through experience (Gray & MacBlain, 2015). As a student gains wider experiences, the learning constructs become more sophisticated. Constructivists value learning by doing with learners being self-motivated and actively involved in authentic learning. Hein (1991, p.1) summarised constructivist learning as “the idea that learners construct knowledge for themselves-each learner individually (and socially) constructs meaning as he or she learns”.

Roblyer, Edwards, and Havrulik (1997, p. 67) explain Piaget's theory of how children follow four stages of cognitive development ending with formal operations when children can "form and test hypotheses, organise information and reason scientifically. Results of abstract thinking are in the form of symbolic materials." Piaget's theory is called constructivist because of its emphasis on students' internal construction of concepts as a result of experiences.

O'Loughlin (1992) cited in Leidener and Jarvenpaa (1995, p. 267) stated: "Based upon the work of Piaget, the learner must have experience with hypothesizing and predicting, manipulating objects, posing questions, researching answers, imagining, investigating, and inventing, in order for knowledge construction to occur." In the senior high school, ICT has a major role in enabling students to experience higher-thinking functions (e.g., Impact Projects involving students in investigating authentic problems relevant to themselves and the local community).

Implications for the use of ICTs in students' learning discussed by Ormrod (1995) cited in Roblyer et al. (1997) are:

- *Students must be involved in an active learning process.*
- *Student knowledge becomes more refined over time.*
- *Students form and modify new concepts through interaction with the environment.*
- *The use of ICTs is integrated into students' learning and available just in time.*
- *Learning is contextual and happens in all areas of students' lives.*
- *Feedback from peers and teachers is necessary for students to refine their learning.*

Figure 5.11 shows the constructivist learning process in the school and how digital tools enhance the learning during the 5 Es of the constructivist learning cycle (Krahenbuhl, 2016). A mixture of software (open source, proprietary and cloud-based) is used by students to support their inquiry learning in a just-in-time way. In terms of the use of ICTs in students' learning, focus-group interviews revealed that students use their BYOD devices, particularly laptops, to collaborate and as a constructive thinking digital tool. OSS is used where appropriate on the school desktop computers, but students mostly use either cloud-based software (Google

Docs) or the proprietary software on BYODs during learning tasks. Google Docs are used for co-constructing learning with peers or teachers.

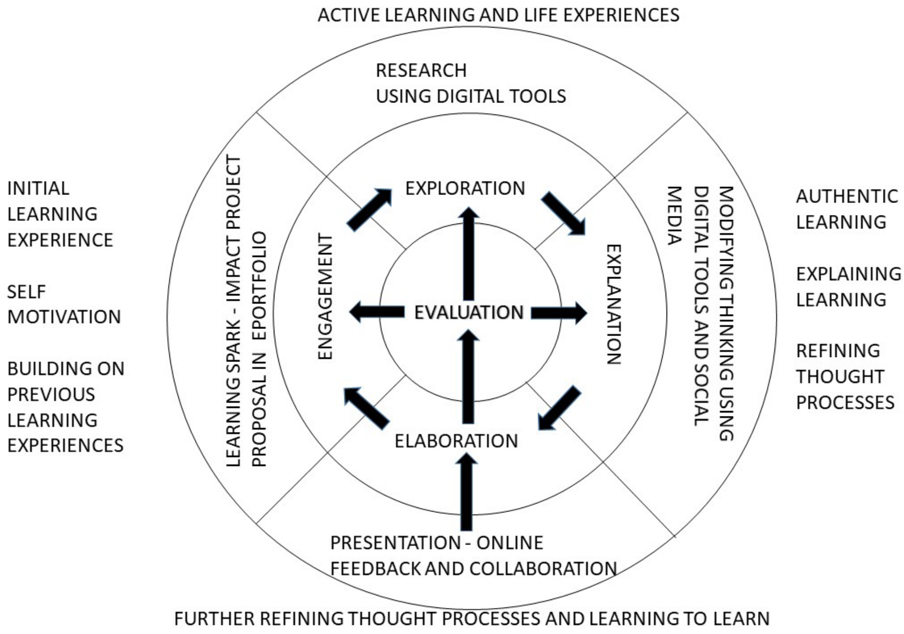

Figure 5.11 Constructivist learning cycle and digitally-enhanced inquiry in case-study school

5.4.1.3 Social constructivism

Vygotsky developed social constructivist learning theory (Verenikina, 2010), which is also known as socio-dialogical or socio-cultural theory. Jones and Mercer (1993) discussed the three main tenets of social constructivism with the first being the vital role that language plays in the learning process because language enables the student to think in new ways and make sense of the world. Second, Vygotsky views learning as a social activity in which learners learn with each other and share each other's discoveries. Third, Vygotsky proposes ZPD (zone of proximal development) as "the distance between what a person can do with and without scaffolding" (Verenikina, 2010, p. 2).

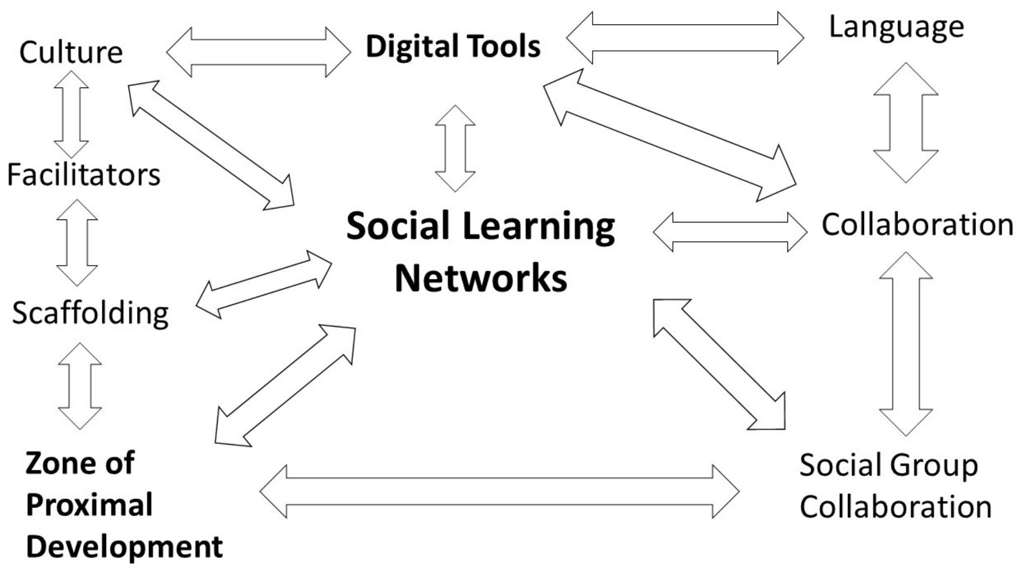

Figure 5.12 Role of social learning networks in social constructivist learning

Figure 5.12 shows the role of social learning networks in learning at the senior high school. Digital tools are the gateway for students to enable social learning in the school through collaboration and communication via social networks. Students indicated they constantly messaged and communicated using BYOD both in and out of school as part of their learning.

Student and teacher feedback in this research highlighted the importance of collaborative learning in the open teaching spaces and on the network. During Impact Projects, students worked in groups at the school and online using Mahara ePortfolio, Google Docs and in Facebook groups. Teacher feedback/guidance was given in Google Docs, which is an example of learning in the ZPD (Verenikina, 2010).

5.4.1.4 Constructionism

Papert (1986) cited Martinez and Stager (2013, p. 32) who first described constructionism as:

> *From a constructivist theory of psychology, we take a view of learning as a reconstruction rather than a transmission of knowledge. Then we extend the idea of manipulative materials to the idea that learning is most effective when part of an activity the learner experiences as constructing a meaningful product.*

As part of their learning, students construct objects or hypotheses. Learning is occurring inside and outside schools when students solve problems by constructing things as part of their daily lives. “Although the learning occurs inside the learner’s head, this happens most reliably when the learner is engaged in a personally meaningful activity outside their head that makes the learning real and sharable” (Martinez & Stager, 2013, p. 32). Constructionism also encourages independent learning because each learner has individual passions and learning needs (Csizmadia et al., 2019).

Technology can be used to support constructionism in a multitude of ways (Stager, 2007) such as facilitating students in constructing a shared mind map, collaborating on a shared document, using program devices such as the Picaxe/Arduino, writing a program and printing an object via a 3D printer. Papert (1991) cited in Litt (2015, p. 17) described the role of computers: “Technology, in this case computers, disrupt the nature of the learning process by shifting from transfer of knowledge to students…(to)…the production of knowledge by students.” Technology becomes totally integrated into students’ thinking processes, and it is used when needed to support the students in the construction and sharing of ideas. In the context of the senior high school, technology is a key part of Impact Projects for which it is used at all stages of the problem-based learning activity.

5.4.1.5 Inquiry

The Impact Project programme in the case-study school is an example of an inquiry pedagogy. Roblyer et al. (1997, p. 68) discussed Bruner and discovery learning which is defined as “an approach to instruction through which students interact with their environment – by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments”. This has evolved into the inquiry process which is used in classrooms today. Kellow (2016, para. 1) defines inquiry as:

> *Inquiry-based learning is a constructivist approach, in which students have ownership of their learning. It starts with exploration and questioning and leads to investigation into a worthy question, issue, problem or idea. It involves asking questions, gathering and analysing information, generating solutions, making decisions, justifying conclusions and taking action.*

Figure 5.13 illustrates the role of ICTs in the Impact Project inquiry process for which ICT is embedded at all stages and is used in a just-in-time manner by students.

Impact Projects run every Wednesday at the school to involve students in selecting an inquiry, planning how to solve the problem, solving the problem and sharing with the school community. OSS supports the inquiry process especially during the planning phase which is shared on the school Mahara ePortfolio.

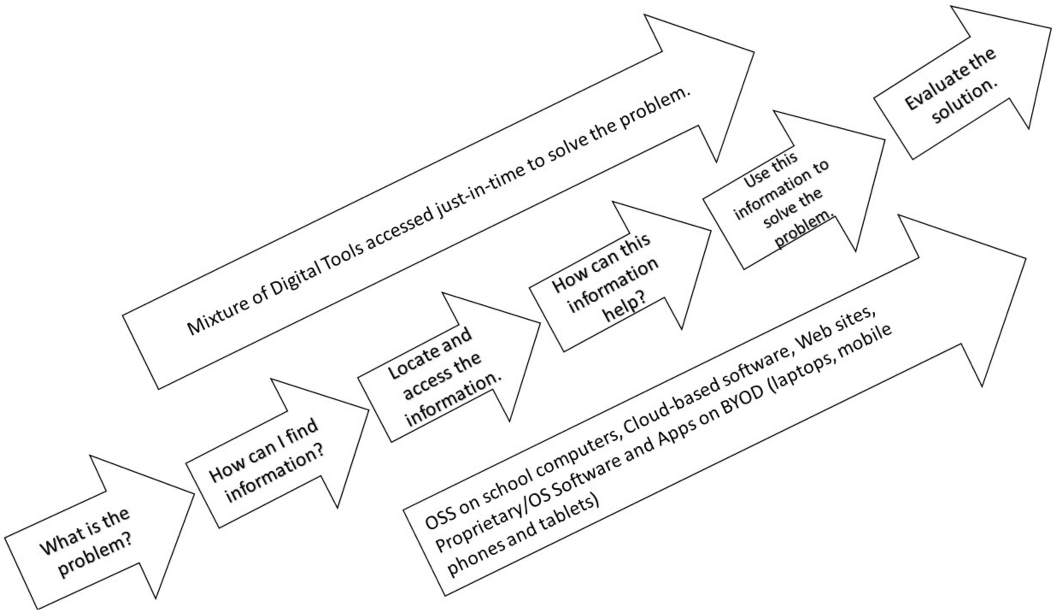

Figure 5.13 Inquiry process and use of digital tools for Impact Projects

In terms of the level of the inquiry, Impact Projects can be classified as guided inquiry (Kellow, 2016a). Mentor teachers assist with the selection of the problem, mentoring is provided during the problem-solving process and the inquiry outcome is not known. When students at the school become more competent, they progress to an independent inquiry level. The levels of inquiry outlined in Table 5.3 range from the confirmation level (the solution already exists and is this level is teacher directed) through to independent inquiry (students conduct the inquiry independently). Impact Projects sit on a continuum between guided and independent inquiry and are a form of problem-based learning, although they are less teacher directed and students have more autonomy (Stanford University, 2001).

Table 5.3 *Levels of inquiry (Kellow, 2016a)*

Level of Inquiry	Student-generated problem?	Students-designed procedure?	Solution is already known/existing?
Confirmation	No	No	Yes
Structured	Yes	No	No
Guided	Yes, with teacher guidance	Yes, with teacher guidance	No
Independent	Yes	Yes	Yes

5.4.1.6 Connectivism

Bell (2011, p.100) stated: "The growth of Web 2.0 services has made the read/write web with people becoming producers of information, in an online presence, a read count, comments, tagging of objects, a remix of someone else's content, or original content." Learners are becoming increasingly reliant on internet connections to access, share, collaborate and solve problems. With the advent of Web 2.0 technologies and social networking, learners are connecting online and working out problems together. Siemens (2005, para. 22) proposed a new learning theory that reflects changes in society regarding learning in networks on the internet:

> *Learning (defined as actionable knowledge) can reside outside of ourselves (within an organisation or database) is focussed on connecting specialized information sets, and connections that enable us to learn more are important than our current state of knowing.*

Siemens (2015) describes the principles of connectivism as meeting the needs of 21st Century learners for whom information currency is sometimes short, learning resides on networks, and ICTs can be used to enhance learning and decision-making processes. Weller (2018, p. 120) described connectivism as "an attempt to rethink how learning is best realised given the new realities of a digital, networked, open environment as opposed to forcing technology into the service of existing practices". Downes (2022, p. 59) argues that connectivism "offers an empirical basis for understanding of teaching and learning, redefining how we think of knowledge, how learning occurs, what we are trying to do when we learn, and how learning is delivered and assessed" in the modern connected, collaborative digital networks which are evident in the case-study senior high school.

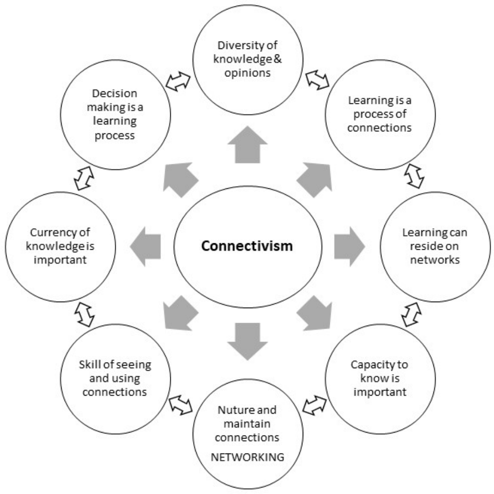

Figure 5.14 Principles of connectivism (Siemens, 2015)

Figure 5.14 portrays the important aspects of learning through connectivism as defined by Siemens (2015). Students learn through the network using cloud-based software, applications and social networking sites such as Facebook. Students communicate, collaborate and share learning experiences on the network. As Downes (2022, p. 59) states, “when a person learns, a connection is physically created between two nodes or two entities on a network”.

Boldstad et. al. (2012, p. 1) argue that “current educational systems, structures and practices are not sufficient to address and support learning needs for all students in the 21st century”. In the senior high school, most students have Wi-Fi connected laptops and smart phones and are constantly networking with peers. The use of ICTs and a mix of software is embedded into the students’ learning on the network, with their thinking and evidence of learning stored on the network. Connectivist learning is evident in the case-study school as students create, collaborate and share learning on the school network using cloud-based digital tools. One female year 13 student commented that “we are on Facebook when we are not on Facebook” which expresses her mindset and connected culture.

5.4.2 Ways of using OSS in supporting pedagogy in classrooms

5.4.2.1 Stakeholders' perceptions of ways of using OSS in supporting pedagogy in classrooms

Board of Trustees members believe that OSS supports learning and teaching within the school and views it as supporting the vision of the school to nurture, to inspire and empower each other (Albany Senior High School, n.d.-b). Because access to software allows personalised collaborative learning (West, 2018) to occur, the Board of Trustees is supportive of the school's use of OSS to enable equal student access to digital tools to support learning.

Because the Linux-based school network runs so efficiently, it allows the IT Technician to focus on locating and installing OSS to suit students' learning needs. Google Apps for Education (GAFE), Mahara ePortfolio, Internet filtering (Watchdog) and the Moodle learning management system are all hosted off site to further free up the IT technician's time. Regular meetings between the IT technician and senior management ensure that the best possible learning experience is available for students on the school network. Any new suggestions for OSS are downloaded and installed on the network for students and network upgrades are scheduled for holiday time to minimise impact on students. The aim of the IT technician is to provide the most up-to-date open OSS and desktop environment for students in the school in order to achieve seamless provision of ICT support for learning.

The senior management's learning philosophy follows the open education movement, which is defined by Creative Commons Aotearoa (n.d. para. 1) as "a global movement working for universal access to education. In particular, the open education movement works to make educational resources more accessible and more affordable". This includes software and learning resources.

In 2012, the senior high school adopted a Creative Commons Policy which ensures that "all teaching materials and policies produced at the senior high school are given a default Creative Commons Attribution 3.0 New Zealand licence" (Creative Commons Aotearoa, 2012 para. 1). The pedagogy adhered to by the senior management is that students should have freedom to access and use educational software without barriers (Wiley & Hilton, 2018). Senior management views OSS as being complementary to the school's vision of nurturing, inspiring and empowering the students (Albany Senior High School, n.d.-b) and to Smith's (2012) definition of pedagogy in which educators look to accompany learners, care for and about them, and bring learning into life. The role of the teacher is as a facilitator who supports and guides students as part of the learning process and learns alongside them (Hipkins, 2011).

Figure 5.15 Freedom of access to open source software for learning

Figure 5.15 demonstrates the senior management's vision for open source software to be a critical part of the learning process supporting student agency. Klemencic (2015, p. 11) defines student agency as "the quality of students' self-reflective and intentional action and interaction with their environment". Open access to relevant software to support learning for all students develops student agency. Figure 5.15 illustrates how a Deputy Principal recalled in an interview that a student produced a website on protecting native skinks in a local park and shared podcasts on the website using open source Audacity sound editing software. Proprietary software was not used by the students because of access and cost.

Impact Projects allow students to choose to a problem-based learning project that benefits the local community (Albany Senior High School, (n.d.-f). OSS is used by the students to plan, research, create, and share the results of their projects using available technologies. If students use their BYOD devices, OSS is optional and students' investigations are not limited by access to software. Students construct their own learning whether in groups or on their own.

The teachers interviewed taught across a variety of subjects within the school and therefore had different requirements regarding use of technology to support their teaching. All teachers used the shared learning commons areas for face-to-face classes. Technology and visual arts teachers had access to computer suites of 30 computers. All students were encouraged to bring their own BYOD devices although their use in class varies between teachers.

Table 5.4 was compiled from the results of 10 teacher interviews to show the variety of both OSS and non-OSS used by teachers. The school supplied Linux laptops to all teachers for class administration, teacher resources and email access to enable them to become familiar with the Edubuntu interface. Visual arts and technology teachers were high users of specialist OSS such as GIMP, Scribus and Inkscape. Through the internet browser, all teachers had access to OSS Moodle and Mahara. All teachers used cloud-based Google for Education for email, cloud storage and classroom application use. Table 5.4 shows the mixture of software used by the teachers on a just-in-time basis.

Year 11–13 students have access to OSS via the school desktop computer pods and through the internet to their ePortfolios and online classes via Moodle. Google Docs, which is closed source cloud computing software, is accessible through the Google for Education school account. During focus-group interviews and web survey, students were asked about the role played by open source software in their learning.

Table 5.4 *Role of classroom software for 10 teachers*

Teacher	Subject	OSS	OSS role	Non-OSS software	Non-OSS role	Tutor, Tool or Tutee
1	Workshop Technology	WiFi network Mahara	Connection to internet Classroom resources	Picaxe CAD	Programming CAD	Tutee Tool
2	Careers	Not mentioned	Not mentioned	Google Apps Facebook	Word Processing Feedback Email Scheduling Surveys Communication	Tool
3	Digital Technology	CAD Web design Project Management Database LibreOffice	Design Web pages Project Management Data management Administration	Google Docs Edmodo	Presentation	Tool Tutee
4	Soft Technology & Design	Mahara	Teacher reflection and Impact Projects	Google Docs Facebook	Assignments Collaboration Feedback Resources Communication Scheduling	Tool
5	Visual Arts Design Photography	GIMP Scribus LibreOffice Impress Inkscape Mahara	Image editor Publishing Administration Presentation Design Teacher reflection and Impact Projects	Facebook	Communication	Tool Tutee
6	Business Economics	LibreOffice Mahara	Administration Teacher resources Impact Projects	Google Docs	Assignments Collaboration Feedback	Tool
7	English	Mahara	Impact Projects	Google Docs Facebook	Assignments Collaboration Feedback Surveys	Tool
8	English Media studies	LibreOffice Writer Impress Mahara	Administration Teacher resources Presentation Student resources	Google Docs Facebook	Assignments Collaboration Feedback Surveys	Tool
9	Accounting	LibreOffice Writer Impress Moodle	Administration Teacher resources Presentation Resources	Google Docs Facebook	Assignments Collaboration Feedback	Tool
10	Visual Arts Design Photography	GIMP Scribus LibreOffice Impress Inkscape	Image editor Publishing Administration Presentation Design	Google Docs	Assignments Collaboration Feedback	Tool Tutee

Students used specialised OSS on the desktop computers. The most-common use was word processing using the LibreOffice software. Because of file incompatibility with Microsoft Office used in their homes, many students used Google Docs as an alternative. LibreOffice was used by students for document creation, but it had compatibility issues with Microsoft Office commonly used at home. There was no school instruction on LibreOffice, even though students would benefit from instruction on the basics especially file saving so that documents can be opened using Microsoft Office. Studies comparing Microsoft Office to Open Office revealed that users in a school reported no significant differences in usability ratings (Vajda & Abbitt, 2011). Pfaffman (2007) highlighted the need for increased training when moving from Microsoft Office to Open Office. Students consistently mentioned that they would benefit from training and hints on the use of OSS. LibreOffice has developed considerably since 2007 and the latest review shows that the differences are now minimal (Stahie, 2015).

The GIMP, Scribus, Blender and Inkscape are all OSS used in specialised subjects such as visual design. Students use OSS as tools to help them to complete their learning tasks for credits towards school qualifications. Students reported that the software is sometimes difficult to use and that OSS comes with a reputation that it is difficult to use. When Moyle and Ruwoldt (2004, p.10) researched two classes of students who had been taught Photoshop and GIMP, they found: "One class learnt GIMP first and the other learnt Photoshop first." When asked about their preferred software, students indicated the software that they had learnt first because it had become the norm. Teachers reported that GIMP was a suitable alternative to Photoshop and that they had specialist training with it. Specialist OSS used in the school had been developed over time and is capable of producing first-class outcomes in the right hands. But, there is a need to overcome the perception that the software is second rate compared with industry-standard proprietary software.

5.4.2.2 School desktop open source software

With the case-study school being located in a high-income area, many students brought BOYD devices to school, including multiple devices such as a laptop and a smart phone. A high number of students reported accessing Google Docs using their BYOD device and that they were not high users of the school desktop computers during school time. Students indicated that they liked that all school desktop computers had the same interface and access to OSS. Becta (2005a, p. 2) reported that students' perceptions of OSS included "lack of familiarity with open source software and the effort required to learn how to use it". Students indicated that they eventually became comfortable with the operating system, but that some training would save time. Waters (2007, p. 4) discussed the development of Edubuntu, the operating system used on school desktop computers, which had been specifically designed for school students and teachers: "not just an operating system, but something that would be immediately useful in a classroom setting – something that would allow a teacher to spend more time teaching and less time managing equipment." Desktop computers are useful in a just-in-time manner for giving students access to a wide range of software that can be used as a tool to enhance learning or access to Google Docs. Some students indicated that it was an advantage to be bi-lingual in computer operating systems (open source and proprietary).

5.4.2.3 Specialist open source software used as a digital tool

Specific OSS programs such as GIMP, Scribus and Inkscape were used by the three visual arts teachers to demonstrate design skills for their students. Students are taught in the computer suites where a projector was used by the teacher to demonstrate skills and tasks. The use of the OSS programs meant that teachers had to source and create teaching resources linked to the specific programs. This required a commitment to learn the software and create/locate resources. Moyle and Ruwoldt (2004, p. 12), in a study of teachers using OSS, found that the main problem was "the necessity for professional development in how to use the open source software in their subject area". A good example of this is the school providing an expert to give the visual arts teachers professional development in the use of the GIMP.

The use of OSS involved constructive pedagogy in which students build on previous experiences and, through experience, become more proficient at using the software and completing set assignments. Students are able to load OSS programs on their home computers to complete or extend work started during school hours.

Because of the school policy of having 100-minute periods, students have a good chance of competing and understanding the activities with the teacher as a mentor and facilitator. Apart from students being able to download and use the software, the use of OSS has not altered the constructivist pedagogy used by teachers. One difference noted was that sometimes students are given the option of choosing software to complete a specific design task, thus personalising learning. This also leads to more-flexible student-centred learning, particularly if students have the software on their BYOD laptops.

For Teacher Three, the digital technology teacher, software is central to teaching students to create websites, databases, computer-aided design and project management. Constructivist pedagogy is used to scaffold skills using projectors and instructional websites. Teacher Three, however, perceived problems with students using software with dated interfaces and instability. Although he does use authentic tasks for his students, he felt that his teaching involves software that students would not use in a tertiary or work environment.

The pedagogy is constructivist with student-centred tasks and software being used as a tool. Whether Teacher Three uses proprietary or OSS in his classroom makes no difference to the pedagogy which would still be constructivist with skills scaffolded by the teacher and mastered by the students in class time.

Although New Zealand has a shortage of qualified IT professionals (Doesburg, 2013), the school still can provide barrier-free access to software for learning IT skills. There is a shortage of women in the IT sector (New Zealand Technology Industry Association, 2015) and student frustration with the technology might prevent female students in the school from succeeding. Evidence from focus groups suggested that female students sometimes have difficulty using OSS.

LibreOffice was used by teachers as a tool for classroom administration because it is loaded on the school-supplied laptop which had Edubuntu software installed. LibreOffice is similar to Microsoft Office (Klosowski, 2013) which is used by the majority of New Zealand teachers on their school supplied laptops, with the Microsoft software sourced from the New Zealand Ministry of Education (2015) software agreement.

5.4.2.4 OSS Learning management systems (LMS)

Moodle is an open source learning management system that is hosted off site as "a learning platform designed to provide educators, administrators and learners with a single robust, secure and integrated system to create personalised learning environments” (Moodle, 2016). Being open source, Moodle is being continually developed, is accessible on any web device, and frees up the IT technician to service the school network. Moodle is an interactive online learning environment which students can use from school and home to provide a personalised learning environment with access to content based on subject preferences.

Teachers reported that Moodle was used as a resource bank to which the teacher uploaded resources for students (e.g., notes if a class was missed or for study out of school hours). Moodle is open source software which has a very large community developer base co-ordinated by Moodle.org. This was a low-level use of Moodle which is an interactive online resource (OnlineLMS, 2016) for involving learners using a constructivist pedagogy. Moodle was hosted externally by the school, but did not have high use by teachers or students. It was also used to host school notices which are displayed throughout the school on TV monitors using student-written OS software.

Teacher Three also reported that he successfully used Edmodo, an online learning management system similar to Moodle (Admin, 2011) and is proprietary software with limited free teacher accounts. Teacher Three preferred Edmodo to Moodle for providing the week’s resources and learning intentions for students to view. Edmodo is used as a flipped classroom to give students access to learning resources from home in preparation for an interactive class lesson (Flipped Learning Network, 2014) and as a communication tool between students and teacher via a mobile app outside school hours.

Feedback from students indicated that Moodle was underutilised in the school and that they rarely used the ‘school intranet’, by which it was known. Moodle was used by teachers as a content repository where students could download lesson content after a lesson, which is a low level of use of Moodle which is a social constructivist learning management system (Costello, 2013). Closed Facebook groups were started by teachers to communicate and interact with students, according to students and teachers during interviews. Teacher interviews and student focus groups identified high usage of Facebook groups and messaging between teachers and students as being highly efficient compared with email.

Teachers and students did not report as present in the class Moodle sites a community of practice or “groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (Wenger, 2006, p. 1). In this case study, students as a group did not use the school Moodle regularly and there was little interaction online. But students and teachers identified a community of practice in the closed Facebook groups, with students actively logging in and engaging with the content and peers.

5.4.2.5 Teacher ePortfolio use

The NZ-developed open source software Mahara is used by the school for planning, sharing and reflecting on learning as part of Impact Projects. Gerbic, Grey, Moore & Bernay (2009, p. 16) defined ePortfolios as “a collection of evidence chosen and collected by the user to form a digital resource”. The school uses MyPortfolio (2020) which is based on the open source software Mahara. Feedback from teachers and students indicated that ePortfolios are used for planning, mentoring, reflecting and sharing of learning during Impact Projects. Uses of ePortfolios are “developmental (to document the growth of personal and professional skills) and reflective (to enable students to revisit practice and reflect on it as a basis for future learning)” (Barrett, 2009 as cited in Gerbic et al., 2009). Zeichner and Way (2009) also suggest using ePortfolios to showcase personal and professional highlights of learning achievements.

Impact Project planning templates were set up in MyPortfolio so that students can copy the template and plan their projects. The Mahara page was shared with mentor teachers for feedback and advice. Because of the nature of Mahara as an ePortfolio, the interface is different from most educational software, training is required. Teachers reported that, because sometimes students had difficulty with the interface, there was a need for specific training. Students in the focus groups expressed frustration with the usability of the Mahara interface. Gerbic et al. (2009, p. 15) recommends “preparing and supporting students in the use of ePortfolios and their use is implemented in a meaningful way”. Gerbic et al. (2009) recommended that ePortfolio use should be a positive experience for students and that technical aspects needed to be carefully managed and supported.

Mahara was also used by teachers for reflecting on their teaching practice for teacher certification purposes. Beginning teachers reflected on their teaching experiences and received feedback from mentor teachers, reported positively about feedback, and felt that the ePortfolio was an effective tool. In a study of beginning teachers, Gerbic et al. (2009, p. 26) found that teachers benefitted from collaboration and sharing with other teachers and that "e-portfolios are also able to support our own learning as teachers, researchers and scholars, both individually, but more powerfully, as communities of learning and practice".

5.4.2.6 Student OSS ePortfolio use

Students reported that the main role of the ePortfolio was in planning and reflecting on their Impact Projects either individually or in groups. Teacher-supplied templates were used for consistency when planning and applying for an Impact Project to be approved. The project plan page was then shared with the mentor teacher for feedback, while students reflected on the project's progress via the ePortfolio page.

All year groups of students expressed frustration with the usability of the interface within Mahara OSS and needed some instruction and familiarity with it. Students liked the ability to share pages and work co-operatively on an Impact Project plan, but were frustrated that only one student could edit the Mahara page at the same time. Students used the ePortfolio page as a link to other resources on the web, such as Tumblr and Pinterest.

ePortfolios support the constructivist and constructionist pedagogy used by the school to enable students to reflect during the learning process, obtain feedback from teachers (formative) and reflect on their learning (summative) achievements (Barrett, 2011). The ability to reflect and obtain feedback and showcase learning (Barrett, 2010) in an ePortfolio is a vital part of the learning process for the 21st century learner.

5.4.2.7 Open source software as a tutee

Teacher One is a workshop technology teacher whose students use technology to design and construct objects as part of the inquiry process. Student learning is hands-on and is facilitated by a constructivist pedagogy, with the role of technology being a tool and a tutee (Taylor, 1980) while students direct the software.

Students learn programming in technology classes using program logic controllers (PLCs). The Picaxe PLC editor is Windows-based, which does not run on the school desktop Linux computers. Picaxe (n.d. para. 2) informs Linux users that PLC editors are available using Visual Studio Code, AXEpad or Blocky. The technology teacher felt restricted because the PLC Picaxe editor was only available for programming on a Microsoft computer, but Visual Studio Code, AXEpad and Blocky editors have since been developed for educational use to enable PLC programming to be taught in schools (Picaxe, n.d.). Other PLCs such as the Arduino are cross platform and could be a useful alternative (Wikipedia, 2021e). The Arduino board can be programmed via a web editor regardless of software platform (Arduino, 2019). The use of the PLCs to control devices leads to high-order constructivist thinking and is a good example of using technology as a mind tool. Jonassen (1996, p .12) explained: "In other words, when students work with computer technologies, instead of being controlled by them, they enhance the capabilities of the computer, and the computer enhances their thinking and learning."

During Impact Projects, some self-taught students choose programming as a tool to create their project. For one Impact Project Wednesday, a student was observed programming OSS software connected to a movement sensor which sent an email when an object moves near the sensor, which is an example of high-level constructivist thinking in an authentic learning context.

5.4.3 Ways of using cloud-based software and social networking in supporting pedagogy in classrooms

Interviews with teachers and students revealed that cloud-based software as a service (SaaS) and social networking were used extensively for learning and communication in the school. Both teacher/student networking (Section 4.4.3) and student/student networking (Section 4.4.4) were perceived as important parts of learning both in and outside the school. Section 5.4.1.5 discussed the connectivist pedagogy in the school, with network collaboration and networking playing a key role in learning and teaching.

Google for Education was provided free to all schools in New Zealand during 2018–2021 by Google (Ministry of Education, 2020) as an example of SaaS cloud-based software. The school had a Google for Education domain which was hosted by Google on its own servers, as well as options for customisation and choosing which apps are available for students. Each teacher and student had his/her own Gmail account, Google Apps for education and storage on Google Drive with their own school login. The IT technician commented that Google for Education frees up his time to concentrate on maintaining the school network.

The majority of teacher and student feedback indicated that Google for Education was used by everyone in the school and was the major ICT tool used by teachers for student communication and feedback on student assignments. Google Docs was used by students for assignments, with teachers giving formative and summative feedback on student assignments via its commenting feature, and for collaborative assignments by groups of students during the Impact Projects. Coutts (2014) described how Google Apps, used in a New Zealand high school, enabled students to drive their own learning, work collaboratively and reflect on their own learning anywhere, at any time and using any device.

In terms of impact on student learning, Google Apps has the greatest influence on learning and teaching within the school. In both the focus groups and the web survey, students reported that Google Apps was used extensively for learning both in school and outside school. Teachers also reported considerable success using Google Apps for giving students feedback on their learning and for facilitating collaborative learning. Google Apps are available on any device, at any time and in any location.

The following reasons were given for the success of Google Apps in supporting learning and teaching by the students and teachers:

- Available at no cost to students
- Everyone having the same software
- Available on any device including laptop, tablet, smart phone or home computer
- Documents being automatically saved and secure
- Documents being accessible from the school or home network
- Easy and transparent student/student or teacher/student(s) collaboration
- Contained within the school domain

- Teachers being able to insert feedback into specific locations on documents
- Teachers and students using the same software
- Students liking the look and feel of the interface
- Google Docs having the basics for editing documents
- Google Apps containing an integrated suite of applications
- Sharing of documents being very user friendly
- Including online storage for documents
- Email providing communication between students and teacher/student
- Both teachers and students being positive about use of Google Apps for learning
- Extensive online support
- Apps being continuously updated and new applications being developed by Google and easily inserted into the suite of available Google Apps.

While not open source software, Google Apps has emerged as the predominant software used for teaching and learning by both teachers and students at the senior high school. Google Apps supports all the pedagogies used in the school and has the advantages of being available on multiple devices and not requiring a login once the initial login is completed on the device.

Many teachers indicated that they use Facebook as a communication tool and resource bank for their students. Hew (2011) defined Facebook as "an online social networking site in which individuals can share personal information and photographs as well as connect and communicate with friends" (as cited in O'Bannon, Beard & Britt, 2013, p. 230). The focus-group interviews revealed that students used Facebook extensively, particularly through their mobile telephones. Teacher Four specifically claimed that a Facebook message was a very effective way to communicate with her students and that she received a higher response rate than with email messages. Teachers indicated that Facebook engages and motivates the students and is embedded into the student culture of the school. Facebook pages and private Facebook groups are used by teachers to extend learning beyond the classroom. Facebook groups are closed in that the public cannot view postings. Facebook is very engaging and almost addictive for students, with a student commenting in a group interview: "We are on Facebook even when we are not on Facebook".

Facebook was used by teachers throughout the school with the mind-set that “if you can’t beat them, join them”. Facebook was part of the student culture both during and outside school hours and an effective way for students to connect with teachers. While it is not open source software, Facebook is free to join and use and is used universally. Asay (2014) reports that Facebook is the world’s largest open source software company, was involved in 255 open source projects in 2014, and had thousands of developers working on its codebase.

Facebook strengthened home–school connections and provided students with seamless connections between home and school. However, student access to Facebook during class is not universally allowed by all teachers, with some teachers reporting that they ask students to turn off Facebook notifications. Students indicated that they adapted to Facebook access between classes and used it for educational uses only during school time.

When O’Bannon et al. (2011, p. 229) researched the effects of using a Facebook group as an educational tool, “there was a significant gain in achievement”. While my research did not specifically measure learning effects of Facebook, focus-group interviews with students suggested that it was very important in students’ learning. O’Bannon et al. (2011) reported that students were very enthusiastic about the use of Facebook for educational purposes and as part of their social lives.

5.4.3.1 Community of practice in cloud-based software and social networking spaces

Teachers and students stated during the interviews that feedback for learning and collaboration occurred in Google Apps for Education (GAFE) and in social networking sites such as private Facebook groups (Section 4.4.3 and 4.4.4). Students and teachers voluntarily participated in the electronic community groups as part of their learning. Duncan-Howell (2010) defines an electronic community as an online space to which members are committed and involved professionally over an extended period of time, with opportunities for synchronous and asynchronous communication. The school is connected by social networks, both within the school intranet and through public social networks such as Facebook and GAFE apps. Students and teachers are constantly messaging, reading and interacting with others online as part of their learning. The school network is a connectivist environment with up to 800 devices connected to the school Wi-Fi at one time. Students and teachers have indicated that they are constantly connected to each other via social networks. The social network groups within the school can be described as a community of practice (Wenger, 2006).

A community of practice is defined by Wenger (2006, p. 1) as: "groups of people who share a concern or passion for something they do and learn how to do it better as they interact regularly". Wenger and Snyder (2000, p. 139) define communities of practice as "groups of people informally bound together by shared expertise and passion for a joint enterprise". Importantly Wenger and Synder (2000) also state that membership of the community is voluntary, which is an important consideration in the context of the school learning environments. E. Wenger-Tranyer and B. Wenger-Trayner (2015, p. 2) have identified three crucial characteristics of a community of practice.

- *"The Domain: Defined by a shared domain of interest and membership is defined by a commitment to the domain.*
- *The Community: Members engage in joint activities and discussions, help each other and share information. Members build relationships that enable them to learn from each other; they care about their standing with each other.*
- *The Practice: Members are practitioners who develop a shared repertoire of resources: experiences, stories, tools, and ways of addressing recurring problems."*

Google Apps for Education (GAFE) is free for all New Zealand schools and enables access to a suite of productivity tools including Classroom, Gmail, Drive, Calendar, Keep, Docs, Sheets, Slides, Sites and Hangouts. Each school subject has its own domain of interest. For example, the media studies teacher would input into the domain whose members include all students in the class. Throughout the school, there are many domains for each subject area. Impact Projects also had a domain, with every teacher overseeing his/her own group of students. Within the domain, the grouping was flexible, with students sharing documents with a specific teacher or teachers. Gmail was used for communication within the domain and all students and teachers within the school have a GAFE account.

Regarding community of practice, within GAFE, the interaction within the school is very high. Both student focus groups and teacher interviews identified very high usage of Google Docs, particularly for teacher feedback on student work. Files can be easily shared with anyone in the school and accessed at any time from a variety of devices. All school emails are managed via Gmail and this is integrated with the Calendar tool. GAFE has a strong community of practice within the school because the cloud-based software is user friendly and can be accessed from both home and school.

GAFE is very closely linked with learning within the school, with shared practice occurring between teachers and students and between students. Multiple students can edit simultaneously and feedback from teachers is timely and focussed. Evidence and a record of student learning is saved within the student's account. Over a year, a shared resource is created with a group of students and resources are shared. Students create their own personal learning environment within GAFE, where all their documents are created, shared and receive feedback from others. In the context of the case-study school, GAFE contributed towards the establishment of communities of practice and as the default tool for students who wishing create documents as part of their study and receive feedback from teachers and other students.

GAFE includes Google+, an online community application, but I did not find any evidence of its use within the school. Google+ was shut down by Google in 2019 (Google, n.d.-a). Regarding GAFE and communities of practice, I located no case studies during a Google search that linked the development of communities of practice with the use of the GAFE apps within a school. Google classroom also is not used within the school because Moodle LMS (called Intranet at the school) is available.

Facebook is a social networking site which is designed for people to connect with each other and share information online (GCFGlobal, n.d.). With Facebook, members can create open and closed groups, but closed groups need an invitation to join and only current members can view and contribute to posts and see stories/content/information about the group (Facebook, 2016). Teachers at the school indicated that they had set up closed groups on Facebook to support their face-to-face lessons. The reason why closed groups are used is that they are exclusively for class members and the content is only relevant to those students and teachers. O'Bannon, Beard, and Britt (2013, p. 230) reasoned that “due to the growth of Facebook and its popularity amongst college students, using this social network in educational contexts can be a potentially powerful idea”.

Pelea (2015) reported that 2 million New Zealanders use Facebook every day. Eighty-five percent of students under 25 years of age access Facebook on a daily basis, usually using a mobile device (Pelea, 2015). Student focus-group feedback indicated that many students have a Facebook account and, during school, they leave Facebook notifications running in the background of their BYOD devices. Facebook is a major part of students’ lives for communication, sharing and information. Both students and some teachers indicated that Facebook is a very effective way of communicating with students. Facebook usage in the school was inconsistent between teachers, with teachers who do use Facebook reporting that communication with students is instant and that students engage positively with teaching resources on a closed group Facebook page.

The domain for learning (Wenger, 2006) is the closed groups within Facebook which are teacher initiated. Students voluntarily ask to join the closed Facebook group to become a member of the community of practice. Similar to the Google Apps, the domain is focussed around a specific subject area and the closed group is administered by the specialist subject teacher. Because membership of a closed Facebook group is voluntary, not all students in a class can be members. The shared activities are centred on asking questions on the topic and sharing resources with the teacher. Links to internet sites also are shared by the teacher.

Students’ participation in closed Facebook groups is dynamic, with students going in and out of the groups. Focus-group interviews provided evidence that students were avid Facebook users constantly connected to Facebook via apps on their personal mobile devices. Focus-group students differentiated between personal use of Facebook outside school hours and educational use of Facebook during school time. Students are expert practitioners of Facebook in the social networking sense and teachers reported a high response rate when using Facebook to communicate with students compared with email.

When O’Bannon et. al. (2013) researched students’ use of Facebook as an educational tool, they found that it can be used to share and discuss course content with favourable outcomes. However, teachers must be comfortable in using Facebook and students sometimes felt overwhelmed with postings and notifications (O’Bannon et. al., 2013). As Selwyn (2009, p. 161) notes, “student use of Facebook involves recounting and reflecting on the university experience, exchange of practical information, exchange of academic information, displays of supplication and/or disengagement and banter”.

Students interviewed about Facebook for this research primarily use it to exchange information and communication with other students and the teacher. Although Roblyer, McDaniel, Webb, Herman and Witty (2010) found that students are more open than teachers to the use of Facebook instructionally, teachers whom they interviewed indicated that they did use closed Facebook groups and were competent users for personal and educational uses. They were comfortable using social networking as part of their pedagogy, but other teachers interviewed were uncomfortable using it for educational purposes. From the students’ perspective, Facebook is a major part of their lives and they engage with it for educational and personal use. Student focus-group interviews indicated that students are able to differentiate between personal and educational uses of Facebook. Overall, Facebook is an effective community of practice within the school when used by teachers, particularly for communication and resource sharing.

Communities of practice is a powerful pedagogy of learning when combined with purposeful-authentic use of networks to collaborate, share and create learning. Google Apps for Education and Facebook are used by both students and teachers to create a community of practice that encompasses both school and home environments. Mobile devices are used to access community of practice platforms where learning occurs at any place or time. The key to students’ voluntary use of GAFE and Facebook was apps on mobile devices that allow easy access and participation/collaboration in cloud-based social networks.

5.4.3.1.1 Community of practice and integration of ICTs into learning

Figure 5.16 represents the roles of community of practices within the school and the ICTs that enable learning to occur. Most interaction occurs online using mobile telephones, tablets and laptop BYOD devices, with students and teachers using suitable ICTs on a just-in-time basis when needed. All technologies are cloud-based and communities of practice can be accessed from school or home on any device. Bates (2014, p. 5) has identified three critical factors that influence the effectiveness of participants in communities of practice:

- *"Awareness of social presence (Individuals needing to feel comfortable in engaging socially with others in the domain)*
- *Motivation to share information for the common good of the community*
- *Ability and willingness to collaborate."*

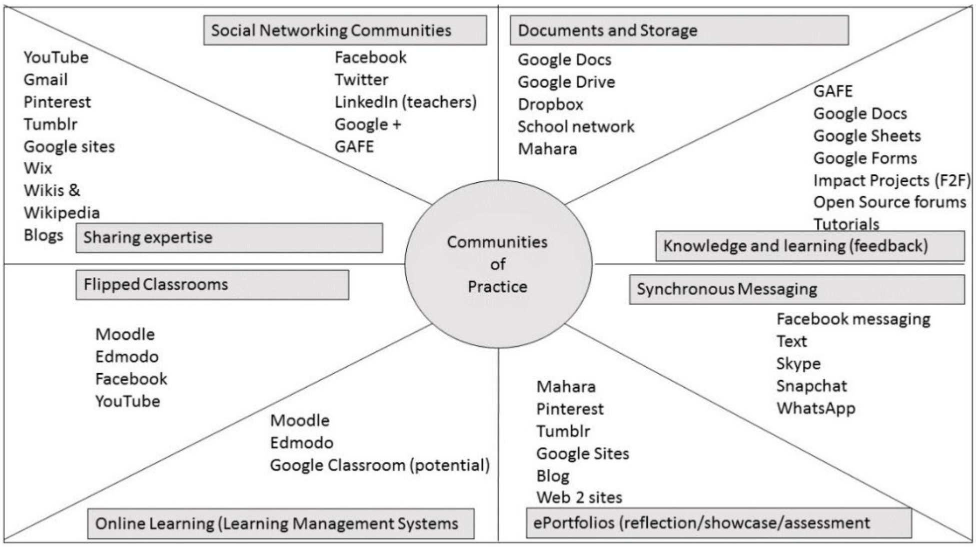

Figure 5.16 Community of Practice and integration of ICTs (Updated by Bates, 2014)

The success of a community of practice relies on the motivation and engagement of the learners within the community, which is reflected in the quality and quantity of the interactions with other community members focussed on learning.

5.4.4 Links between the learning theories relevant to the mixture of software used to support learning in the senior high school

The roles of open source software, cloud-based software and proprietary software are summarised in the Figure 5.17 below. Pedagogies used in the school are supported by a mixture of open source, cloud-based and proprietary software. Social networking software also supports the connectivist learning space in the school. Interviews with students indicated that they often communicate and collaborate in a connectivist environment via their mobile telephones and laptops.

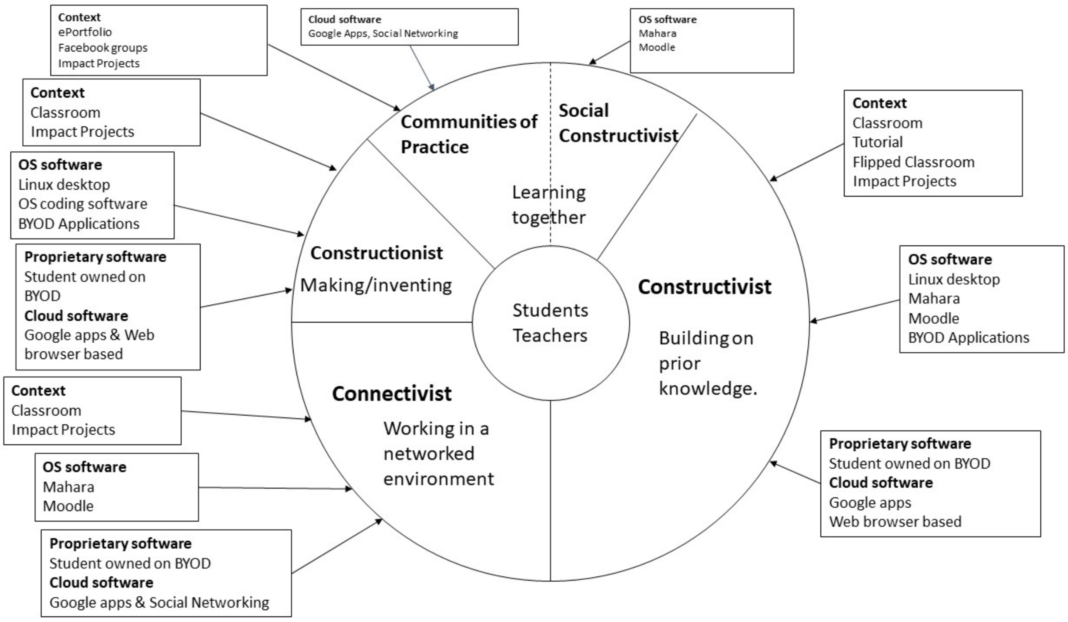

Figure 5.17 Pedagogy and role of software

Figure 5.17 illustrates the links between the main learning theories relevant to the senior high school and OSS, proprietary and cloud-based software that students and teachers use to support learning. Each type of software has a role in supporting learning and is selected by the student when appropriate. OSS and cloud-based software removes the barrier of choice.

The high school had open source software installed on the school network and on desktop computers in computer suites and pods located in the learning commons. Moodle LMS and Mahara ePortfolios are open source software based in the cloud (contracted to external providers) and teacher laptops run open source software (Ubuntu). Student devices including laptops used proprietary software, but some students had installed Windows versions of OSS programmes. Mobile telephones and tablets had Android or iOS software with free apps installed.

5.4.5 Ways of using a mixture of software in supporting pedagogy in classrooms

My research identified a mixture of digital tools used by teachers and students in classrooms. OSS is part of this mixture that supports learning in the school in a just-in-time manner. The combination of open source software, closed source cloud-based software and proprietary software was used seamlessly throughout the school to scaffold learning and teaching. Open source powers the school network and Wi-Fi reliably and efficiently. School desktop computers allow student access to OSS programs for specific learning needs and internet resources. Open source cloud-based tools such as Mahara ePortfolio were used for planning, refection and sharing of evidence of learning, while the open source learning management system Moodle is hosted in the cloud. Closed source cloud-based school email, storage and Google Apps for Education are hosted by Google. Students predominantly use their proprietary software on BYOD laptops in the classrooms, with tablets using proprietary or open source operating systems and mobile telephones using either proprietary or open source operating systems and applications.

When teachers and students discussed the influence of technology on their learning and teaching throughout the school, Google Apps for Education was identified as open source software that is freely available/accessible and works well on any device that is connected to the internet.

5.4.5.1 Impact Projects

The Impact Project programme follows inquiry pedagogy with students choosing an inquiry/problem to solve to benefit the local or wider community. Students are in charge of their own learning in choosing a topic, presenting a proposal to a committee, planning how to solve the problem to achieve their goal, implementing their plan and finally presenting the results of their project to an audience (Albany Senior High School, n.d.-d). Wednesdays are timetabled for all students to work either in school or out in the community on Impact Projects which are cross-curricular and students' sixth subject of study. A male student defined Impact Projects as: "you can start a project, design a project that will somehow benefit the community and make you learn stuff you wouldn't learn inside a classroom or in a specific subject." A female student stated that "you can focus on a passion you have that you won't get to learn inside a normal classroom." Students also explained the benefits of Impact Projects:

> *I believe that Impact Projects not only help you do what you want, but also help you become more independent because Impact Projects are mainly focussed by yourself and there's not as much impact from teachers. It helps you develop skills that you can work independently and time management etc… and all of that so you can become more ready for getting a job outside of school which I think only the school can offer.*

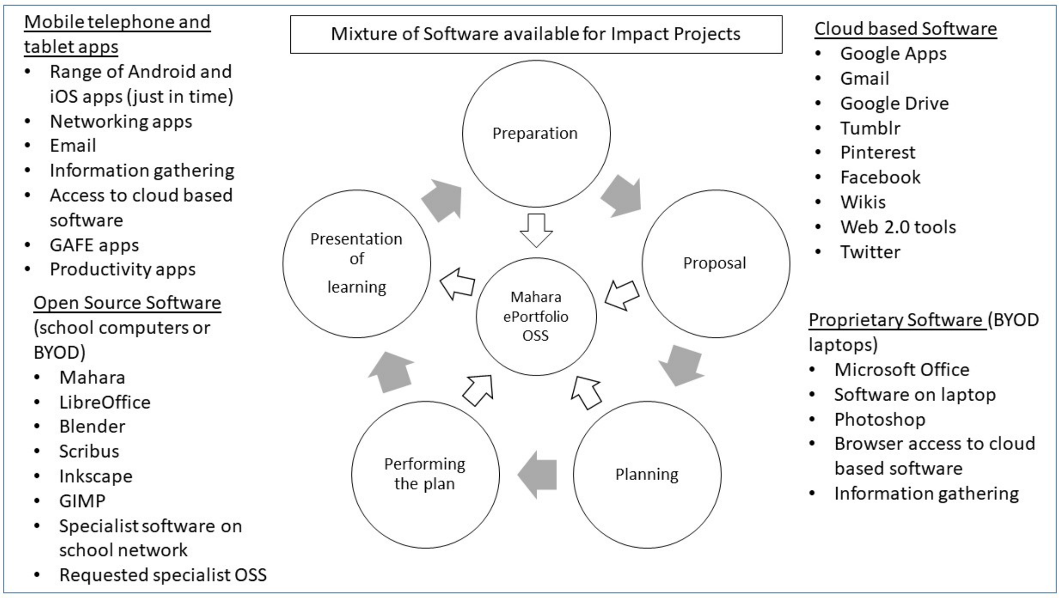

Figure 5.18 Impact Project process and software mixture

Figure 5.18 shows that a key part in the Impact Project process is the open source ePortfolio software used by the students to plan projects (using a template) and prepare proposals for acceptance. Students then reflect regularly on the ePortfolio page, which is shared with teachers for regular feedback. Barnstable (as cited in Barrett, 2010) identified the benefits of ePortfolio reflection as including increased depth of learning, enhanced self-esteem and more autonomy in learning. ePortfolios are central in supporting independent learning during Impact Projects. Mahara ePortfolio access is through MyPortfolio which is sponsored by the Ministry of Education nationwide and is hosted externally with regular updates to the software.

The mixture of available software includes open source, mobile app, cloud-based and proprietary software. Students use whatever software suits their needs and available devices at the time without necessarily thinking about its source. Software is used as a digital tool (Fullan & Langworthy, 2014) to facilitate deep learning and engage with the community of practice within their Impact Project.

5.4.5.2 Impact Project pedagogy

Impact Projects are based on constructivism, social constructivism, constructionism and connectivism. Fullan and Langworthy (2014) propose a model for new pedagogies suited to deep learning and which inform Impact Projects (Figure 5.19). Fullan and Langworthy (2014) argue that deep learning tasks necessary for 21st century learners can be achieved by new partnerships with the learner (with the teacher taking a more-active enabler role in guiding the learner) together with access to digital tools and resources with which the learner can become more engaged and better prepared for a technological society. Deep learning tasks are focussed on authentic learning and creating knowledge instead of replicating it as in the old paradigm. Figure 5.20 illustrates how the Impact Project concept can facilitate learners using Fullan and Langworthy's new pedagogies.

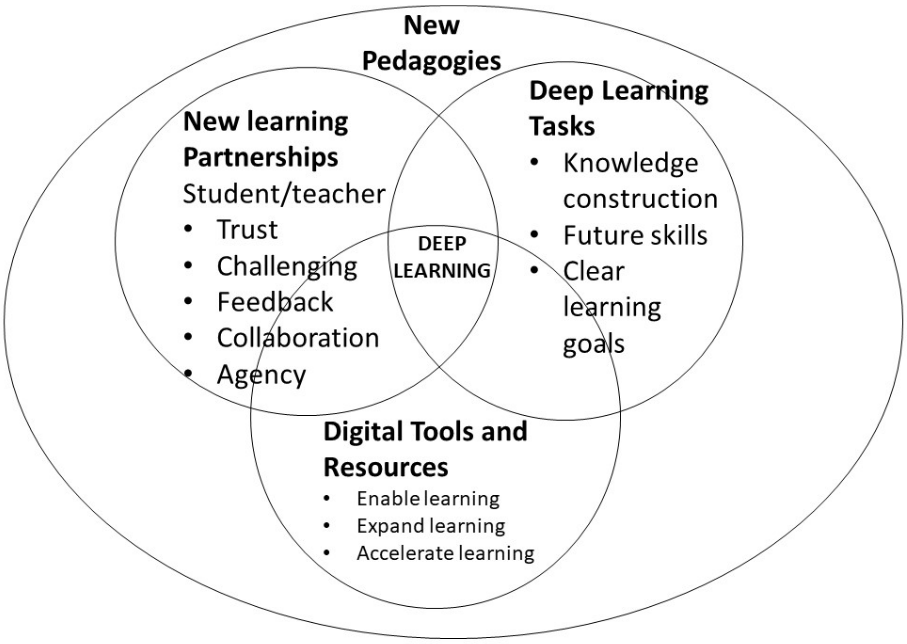

Figure 5.19 Core concepts of new pedagogies (Fullan & Langworthy, 2014).

Figure 5.20 illustrates how Impact Projects are linked to Fullan and Langworthy's new pedagogies for 21st century learners. The community of practice established around learners supports Impact Project goals, provides feedback and guidance and celebrates achievements, with digital tools facilitating deep learning through authentic engaged inquiry. OSS provides the glue (ePortfolios) and its availability on the desktop computers and BYOD laptops provides just-in-time digital tools for the learning task. Open source, cloud-based, mobile telephone apps and proprietary software combine in the mixture available to students. Learners become most passionate about their learning goals and are more self-driven to prepare, plan and action their learning projects.

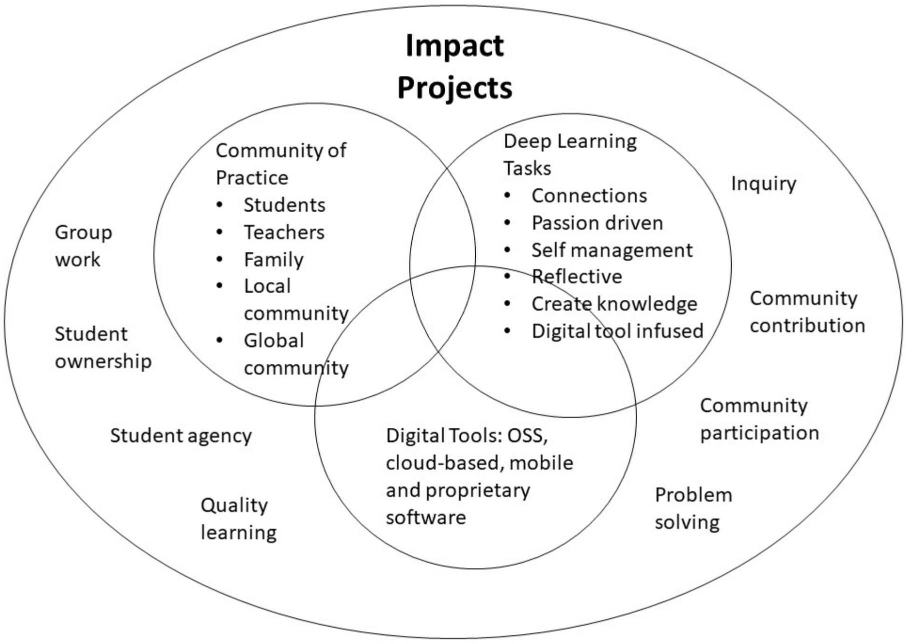

Figure 5.20 Impact Projects and links to new pedagogies and community of practice

Table 5.5 illustrates that, when teachers create a supportive learning environment through Impact Projects, the development of lifelong learners is nurtured, inspired and empowered through the New Zealand curriculum goals of (Ministry of Education, 2007b):

- Literacy and numeracy
- Development of critical and creative thinkers
- Active seekers, users, and creators of knowledge
- Informed decision makers.

Table 5.5 *Link between Fullan and teacher pedagogy and Impact Projects (Adapted from Fullan and Langworthy, 2014, p. 13)*

Teachers (Pedagogical Capacity)	Impact Project Evidence
Build trusted relationships with students and peer teachers; seek good mentors	Teachers mentor individual students or groups of students during Impact Projects.
Help students find and build on their interests and aspirations through deep learning tasks	Teachers support students during all phases of Impact Project process and encourage students to follow their passions.
Require challenging learning goals, tasks and success criteria for self and students that require creation and use of new knowledge	Teachers mentor and support students during preparation and proposal stage in order that goals are specific and achievable.
Develop repertoire of teaching strategies; use different strategies to activate learning	Learning is personalised and students choose their preferred learning style for developing their learning goal.
Provide high-quality feedback and encouragement, especially when students face challenges in learning	At all stages of the Impact Project process, teachers provide feedback in both face-to-face and digital form via ePortfolios, email and instant messaging. Students approach teachers to help solve any problems or challenges.
Collaborate with other teachers and leaders to research the impact of different learning strategies on students (i.e., use an inquiry cycle approach)	Impact Projects use an inquiry approach with students solving an authentic problem to reach a learning goal. Reflection and evaluation are key parts of the process.
Model a proactive disposition towards learning, creating new knowledge and taking action with that new knowledge	Teachers are actively involved in the learning process with students; students are the experts and teachers take a facilitator role.
Continuously discover and create digital learning tools and resources to: 1) explore new content, concepts, information and ideas 2) challenge students to create new knowledge 3) connect with students, peers, and experts beyond the classroom 4) accelerate students' ability to drive their own learning process and assess and share information on students' learning abilities and dispositions.	Students and teachers are free to locate OSS that is suitable as a digital tool and can be downloaded and installed on the school desktop computers. Suitable cloud-based software can also be utilised as part of the Impact Project. Students can also download and install apps on their phones or tablets to enable learning for their Impact Project.

Table 5.6 *Link between deep learning pedagogy and Impact Projects (Adapted from Fullan & Langworthy, 2014, p. 13)*

Students (Deep Learning)	Impact Project Evidence
Build trusted relationships with teachers and peers; seek good mentors	Students choose a mentor teacher with whom to work throughout the inquiry
Explore own interests and aspirations in learning goals and tasks	Students choose their own area of inquiry according to their interests and passions.
Develop capacity to define learning goals, tasks and success criteria; partner in the learning process	In the preparation and proposal stage, students develop their own learning goals, tasks and success criteria.
Reciprocal teaching and learning from and with peers and teachers	Students often work in groups and learn from each other and experts.
Develop capacity for refection and perseverance in the face of challenges; provide high-quality feedback and encouragement to others	Students reflect in an ePortfolio throughout the project while mentor teachers, peers and family provide feedback and encouragement.
Provide feedback to teachers and peers on what is working in one's own learning; build mastery of the learning process and one's own progress	Evidence of learning journey is recorded in the ePortfolio. One-to-one conversation with mentor teacher.
Develop intellectual and attitudinal dispositions towards creating new knowledge and doing things with it in the world	During Impact Projects, students create knowledge and share artefacts to improve their community.
Continuously discover and create digital learning tools and resources to explore new content, concepts, information and ideas. Use these tools to create new knowledge, to connect with peers and experts throughout the world and to use new knowledge in the world	Students select the appropriate digital tool to scaffold their thinking. Knowledge is created during the Impact Project and shared with the school and local and global community using networking tools. Availability of open source software widens the digital tool choice.

Table 5.6 illustrates the student's learning role during the Impact Project process as an independent self-motivated learner who sets learning goals, plans for learning, implements the plan, and evaluates and shares the goals with the community. Open source ePortfolio is the catalyst or glue in the Impact Project process, while the ePortfolio allows students to develop learning goals, share these with the mentor teacher and continually reflect during the Project. The availability of the OSS allows

the student to select a digital tool to use during the inquiry process (in addition to cloud-based or proprietary software if needed and available).

5.4.5.3 Teacher's role in Impact Projects

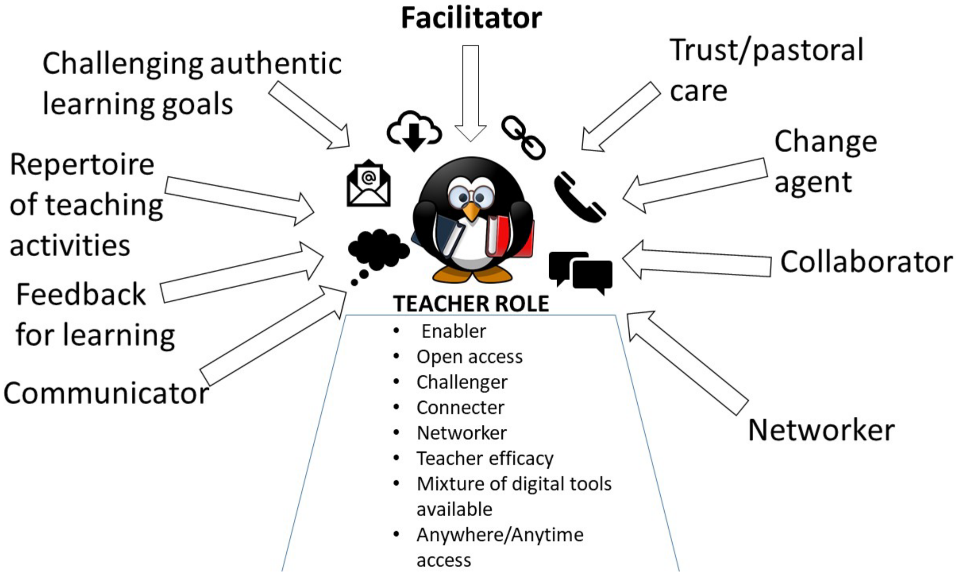

Figure 5.21 Teacher's role in Impact Projects

Figure 5.21 demonstrates that the teacher's role in Impact Projects involves interacting with students and moves from one group or individual student to another, discussing progress and providing feedback. The teacher also has an online role in accessing student ePortfolio planning pages and providing online feedback/suggestions on progress with Impact Projects. During the preparation phase, challenging learning goals would be facilitated and the teacher would mentor the formulation of the proposals and assists in the planning. During the implementation of the plan, students contact the teacher for advice either via email or social networks. The teacher advises on the presentation and links learning goals to school achievement standards. The internet icons represent the online interface between the teacher and the student.

OSS played an important role in the digital tool platform. The OSS ePortfolio was the reflective digital tool that was key to the Impact Project process. The just-in-time availability of specialist OSS allowed students to scaffold deep thinking strategies and enable solutions. The digital tool mixture, together with cloud-based software and proprietary software, enhanced the learning process.

5.4.5.4 *Students' role in Impact Projects*

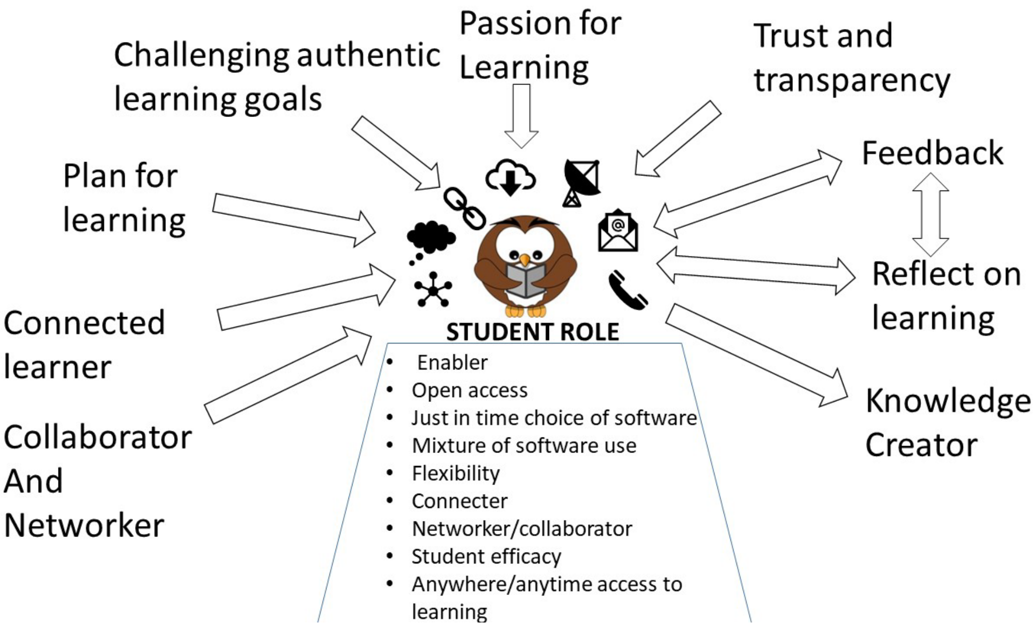

Figure 5.22 Students' role in Impact Projects

Figure 5.22 shows students' role in Impact Projects. The internet icons represent the important connection between student and facilitator both in and out of class. Passion drove students' learning during Impact Projects. Students selected their inquiry topics and goals for learning and reflected on their learning progress on the Mahara ePortfolio. Teachers mentored the learning process while students collaborated with peers and experts. The student's role was built on the digital tool platform in which OSS played a significant and just-in-time role while students accessed specialist software to enable them to solve problems and connect with peers, teachers and experts. Cloud-based software, social networking and proprietary software also played a role in the provision of digital thinking tools to enhance the solution of the Impact Project problems.

5.5 Summary of Findings to Research Questions

5.5.1 Research Question 1: What do stakeholders perceive open source software to be?

Section 4.2 reported the results for school stakeholders' opinions about OSS, whereas Section 5.2 further discussed stakeholders' understanding of OSS. A wide variety of interpretations of the meanings of OSS was found among stakeholders.

Generally, most senior management members and teachers identified a wide range of attributes of OSS, whereas students identified a narrower range of attributes. In the focus groups, particularly for year 11, female students had limited understanding of the attributes of OSS, but male students were more confident in discussing its attributes. The level of understanding increased throughout the year levels for both male and female students, although there was some confusion about SaaS (Google Apps). Understanding of the meaning of OSS is grounded in the context of education and the availability of educational software for all relevant stakeholders. Stakeholders were aware of the use of OSS within the school and that it was part of the school's open culture. Student feedback suggested that information about open source software would be useful for students' understanding of its use to support learning, particularly among Year 11 and 12 female students. Teachers also indicated that a shared understanding would be useful for implementing OSS in their teaching practice. The Open Source Initiative (2014) definition centred around the freedom to modify the open source code and free distribution was central to all stakeholders' understanding of OSS, which enabled barrier-free access to software for learning within and outside the school.

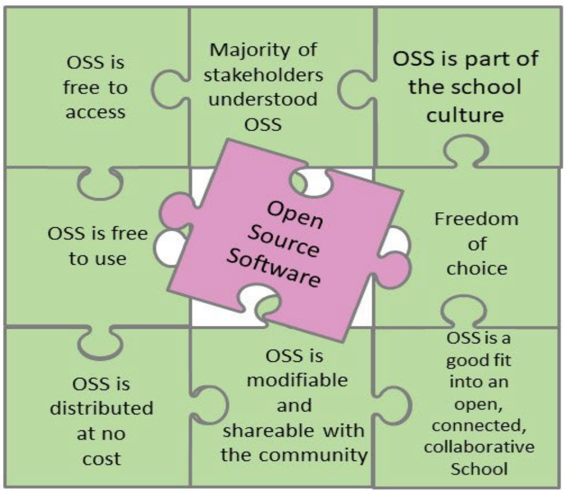

Figure 5.23 Summary of school stakeholders' definitions of OSS as used in the school

Figure 5.23 illustrates school stakeholders' shared understanding of the definition of OSS and how it fits with an open, connected and collaborative school. Open source software was introduced at the beginning of the establishment of the school and has become accepted as part of the school open culture.

5.5.2 Research Question 2: What do stakeholders perceive are rationales for use of open source software?

Section 4.3 reported rationales for the use of OSS in the high school, whereas Section 5.2 discussed implications for its use. All stakeholders supported the use of OSS but they had a variety of views about the rationales for its implementation. Cost effectiveness was a common rationale for all the stakeholders because money saved was able to be spent elsewhere in the school. Freedom of access to OSS meant that teachers and students had a wide choice of educational software to support their learning. Open access to open source software supported the school vision "to nurture, inspire and empower each other, . . . achieve highly and become good citizens" (Albany Senior High School, n.d.-b, para. 1). OSS fitted into the open educational philosophy of the school (open plan architecture, open teaching spaces, open educational resources, encouragement of BYOD in class, open networks/ePortfolios and a collaborative/personalised/networked pedagogy). OSS was a catalyst for educational change (Twining, 2007).

Senior management and teachers also saw OSS as bridging the digital divide by giving students equitable access to specialist educational software via school computers or BYODs. Pedagogy was also a common rationale, with teachers and students perceiving that access to OSS was linked to supporting flexible learning within the school. All students had open access to specialised software in a just-in-time manner to support specialist curriculum areas and inquiry within the school using either school computers or BYODs. Students had open access to OSS from both school and home, while teachers and students had seamless access to appropriate software to support learning and student agency. Open access to software enabled teachers to focus on pedagogy and digital tools to promote deep learning (Fullan & Langworthy, 2014), while students could create their own personalised learning environment supported by access to digital tools which are a catalyst for their learning (Fullan & Langworthy, 2014).

All stakeholders agreed that OSS supported the school's open educational philosophy, its special character and inquiry-based Impact Projects through specialised software to support their specific community-based inquiries. Students were able to create open source software for use within the school for teaching or administrative purposes (e.g. the digital signage display software). The use of OSS has been linked to the transformational rationale through the Impact Project programme (Twining, 2007). Regarding software access, the school was pragmatic and flexible: if OSS did not meet student learning needs, then access to specific proprietary software was enabled (e.g., Final Cut Pro video software on a pod of Apple computers).

This research revealed that OSS was used as part of a mixture including subject specialist subject software, learning management system software, and ePortfolio and productivity applications supplemented by cloud-based software for networking and productivity, mobile telephone applications and proprietary software on BYOD and home devices. Software use by students is governed by the need and availability in a just-in-time manner Figure 5.24 summarises the many different rationales for using OSS in the school to support the school vision of facilitating student achievement. Open source software is part of the school culture.

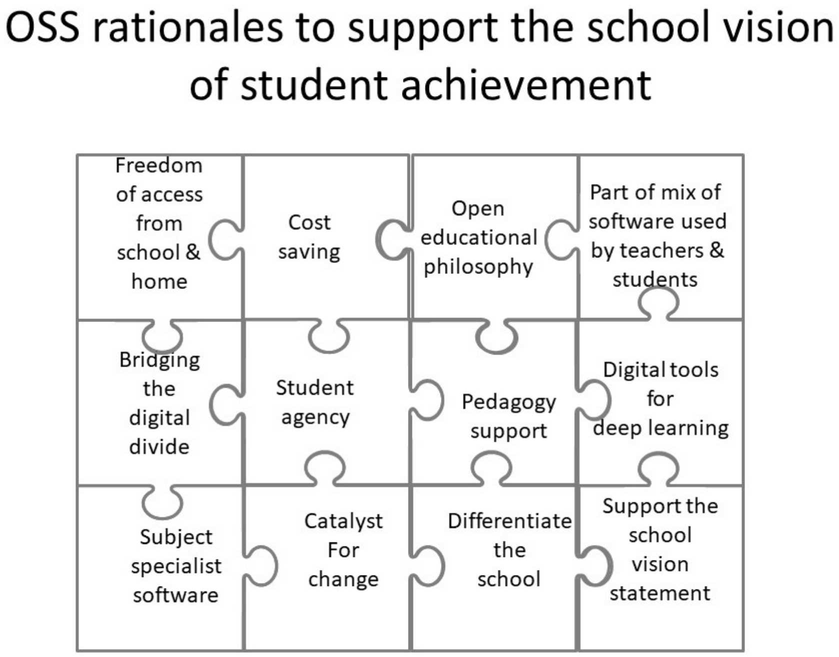

Figure 5.24 Rationales for use of open source software

5.5.3 Research Question 3: What do stakeholders perceive are the advantages and disadvantages of open source software in educational context?

When stakeholders were asked their opinions about the use of open source software in the school, both advantage and disadvantages were identified (Sections 4.4 and 5.3).

6.3.3.1 Advantages of open source software in educational context

Advantages of open source software in the school were previously identified in Section 5.3. The main themes regarding the advantages of open source software use in the school are summarised and synthesised below. Open source software is a good fit with the school's open philosophy, including open architecture, open educational resources, Impact Project choices and open technical infrastructure of technology use. The teacher's role was as a facilitator of student self-directed learning that is supported by a software, whether open source, cloud-based, social networking or proprietary software. Openness is very highly valued within the school.

OSS use is sustainable in that the school has the choice to modify the code to suit its use for learning. The school has access to a wide variety of open source software to load onto the school computer network to meet students' learning needs, but there is no pressure to continue using it as would be the case if proprietary software was purchased. The school can also take advantage of free ongoing software upgrades to instal in a non-disruptive way during a holiday break. As new software is developed, it can be installed on the network on demand and integrated into the learning environment within the school. Students can also develop their IT skills in creating or modifying software for use in Impact Projects. The new OSS or improvements can then be shared with the OSS community for the public good.

Access to specialised software for all students was important for senior management and teachers for bridging the digital divide. OSS on the school computers allowed all students to access and learn to use specialised educational software to support their learning in all subjects. The software could also be loaded onto BYOD devices or home computers.

The role of technology in the school is to support pedagogy and enable learning (Fullan & Langworthy, 2013). OSS is part of the mix of technology that supports learning, collaboration and communication in the school. Self-directed learners, particularly during Impact Projects, use technology to support high-level thinking using constructivist, social constructivist, constructionist and connectivist pedagogies within the school community of practice. The student is at the centre of the learning process and a mix of technology is used as a digital tool at all stages of the learning process. The role of the teacher is to guide and facilitate learning while students choose in a just-in-time manner from a mixture of open source, cloud-based or proprietary software to scaffold their learning.

Cost savings are a major advantage in that the school does not have to pay for specialist proprietary licences for specific software in different curriculum areas. Through the Ministry of Education (2014b) software license, the school gets free access to Cloud-based Google for Education software that is used extensively throughout the school on student devices for collaborative and connectivist learning. Cost savings are also available to students who can load OSS onto their BYOD. Importantly, there is also no cost for the networking software, the learning management software Moodle, and ePortfolio software. School technicians manage the school network and use the open source community of practice to resolve technical issues.

OSS provides security and virus protection. With OSS, no anti-virus software was needed on the school network. Having a secure network meant that the school IT technician could devote his time to ensuring that the network could run smoothly, installing and monitoring network software, and maintaining the WiFi network to ensure network access for teachers and students.

OSS is part of the mix of software used by stakeholders in the school as part of the learning process. Although students do not make a conscious choice of software, they use what works for them for particular learning tasks. For graphic design, students use The Gimp, Inkscape or Blender; for collaboration, students use a Mahara page or a Google Doc; for communicating and chatting about a learning concept, students choose social networking software such as Facebook; if a formal query is needed, then school Gmail is used; and, if a document needs to be created, then Microsoft Word, Libre Office or Google Docs is used. Because the source and type of software does not matter, students choose the software (whether Cloud-based, OSS, proprietary or social media based) that gets the job done quickly and efficiently. Importantly, the document or product must be able to be shared with a peer or teacher for feedback. For this reason, although OSS has a role as specialised subject software, Google docs was the most-commonly used software among students and teachers within the school because it can be accessed from BYODs, school computers, mobile telephones and tablets owned by students.

6.3.3.2 Disadvantages of open source software in educational context

The main themes regarding the disadvantages of open source software use in the school are summarised and synthesised in this section. Students and teachers complained about file incompatibility between proprietary and OSS software*,* with transfer of Word documents between Microsoft Office and Libre Office losing formatting features. Askubuntu (n.d.-b) has provided solutions for ensuring compatibility now that both office suites have matured to make the transfer process easier (Wallen, 2015). Students indicated that professional development within the school would help them to transfer files seamlessly between OSS and proprietary suites.

The technology teacher expressed frustration that programme logic controllers *(PLCs)* were incompatible with OSS because they were designed for use with Microsoft software. Because no OSS solution was available, laptops with Microsoft software were used. Another solution is to use a computer on wheels (COW) when PLCs are used with the students. A longterm solution involves purchasing OpenPLCs (Alves, n.d.) and devices such as the open source micro:bit (Edsurge, 2016) which rely on a browser interface for programming and eliminate the need for a proprietary software on a device. A digital technology curriculum has recently been introduced into the NZ Technology curriculum (Ministry of Education, 2018b) in which the use of hardware such as PLCs becomes embedded in school classrooms.

Teachers and students commented that the OSS interface was less user-friendly than the proprietary software equivalents, with more steps involved to complete a task. Stakeholders agreed that the completed product was the same. Teachers needed to develop scaffolding to guide students in using OSS via video tutorials and help documents. For example, to assist teachers and students, the school employed a

GIMP specialist to provide workshops for the teachers to develop help guides for students. The solution is to provide extra scaffolding for students in specialised help docs or help guides on the Internet (e.g., video tutorials on YouTube).

The information technology specialist teacher and some visual arts teachers were concerned that students would not be exposed to the proprietary software that they will use in their industry careers. Open source supporters consider that many of the software short-cut keys are the same as for proprietary software and that students learn generic software skills, whereas proprietary software supporters mentioned a more user-friendly interface, retailer support, no need for extra training before using it in a career, and the mindset that proprietary graphics software is superior (Singh, Bansal & Jha, 2015). Teachers believed that the end product from open source graphics software is the same except that the process can be longer and more complicated.

Some teachers identified a lack of teaching resources to support OSS. Teachers who apply to work at the school are made aware of the use of OSS throughout the school, but specialist teachers who use specific software need to develop new scaffolding for students to use. The school has started employing specialists in OSS to assist teachers in developing resources. As OSS is developed by a community of developers, there are many resources on the use of the software available on the internet. All OSS has a website with help guides and sites such as YouTube are available.

Some students identified a lack of school support for using OSS, including website help. More student involvement with OSS in the case-study school, similar to Penn Manor School District where students are involved with loading OSS onto student laptops, coding software and running a help desk in schools for teachers and students (Reisinger, 2016), would give students more understanding and ownership of OSS use.

Teachers noted a lack of professional development in using OSS in their teaching. Software help resources can be developed for both teachers and students and loaded onto either a school Moodle or Google sites for easy access. Help files and videos could be added on a continuous basis.

5.5.4 *Research Question 4: What do stakeholders perceive is the pedagogy used in classrooms in relation to open source software?*

Pedagogy is "the thinking and practice of those educators who look to accompany learners; care for them; and bring learning into life" (Smith, 2012, para. 1). The school's vision identifies warm positive relationships between teachers and students as being essential for learners to thrive (Albany Senior High School, n.d.-a). Siemens argues that 'Our technology is our ideology' (McNeal, 2016) and that access to learning through technology is likely to hone unique human traits and develop learners who thrive in an increasingly-technological world. Technology supports the school vision that "we nurture each other, we inspire each other, we empower each other to achieve highly and be good citizens" (Albany Senior High School, n.d.-i, para. 1).

The high-level thinking learning theories of constructivism, social constructivism, constructionism and connectivism are the basis of the pedagogies used within the school to support learning. From the school's beginning as a new school, ICTs were part of the school infrastructure and learning culture, with OSS removing barrier to access for students and teachers. Students are encouraged to bring their own devices to school to connect to the school network as part of their learning and the open educational culture in the school.

Inquiry learning is a major part of the school pedagogy through the Impact Project programme that takes place every Wednesday. Students select an inquiry project based on their passions and strengths to help the local community, plan how to solve the problem or issue, solve the problem by creating a solution/artifact, and share their solution with the community. The mixture of software in the school supports all stages of the inquiry process through the use of: Mahara ePortfolio for scaffolding the planning and feedback from mentors; specialist OSS on the school computer pods and student devices; BYOD proprietary software; or cloud-based software for solving the problem and sharing the solution through the school network. The mixture of software provides scaffolding to support constructivist, authentic, hands-on learning. Increasingly, connectivist learning is becoming more important for students for collaborating, sharing and working in cloud-based learning environments through Google docs, social networks and Web 2.0 websites. Students indicated that they communicate primarily through social networks because of the immediacy, with students always being connected via a mobile device. Students learn in a connectivist learning environment where learning takes place both in their minds and on the network (Siemens, 2005).

Senior management's vision for pedagogy within the school follows the open education movement for which learning in the school is 'open' for everyone in terms of school architecture, pedagogy, software access and learning resources. All students have equal access to learning opportunities while teachers play a facilitation role in guiding and scaffolding learning. Teachers have access to educational OSS on their school laptops and OSS specialist software on school computer suites and pods in the learning spaces. Students have a choice of software to support their learning and chose from the mixture of software available (OSS on the school computers, Proprietary or OSS on their BYOD laptops, and app software on their mobile telephones or tablets). Students made an individual choice about which software best suited their learning purpose. Specialised OSS was used for Design/Photography and Visual Arts on school computers, proprietary software was used on BYOD laptops, and cloud-based software (Google for Education) was used for document creation/collaboration.

This research revealed that cloud-based software such as Google for Education is becoming increasingly important in learning because Google Apps runs on multiple devices, is accessible from any location, enables students and teachers to collaborate on documents, and allows teachers to scaffold learning using feedback/comment functions. Social networking was primarily used for communication/collaboration and sharing of ideas and classroom follow-up on private Facebook groups on mobile telephones. A mix of software was used by students in a just-in-time manner depending upon the learning circumstance because students typically carried a mobile telephone and laptop around with them at school.

Through the extensive use of social networking, cloud-based software and Mahara ePortfolio software, an online community of practice (Wenger & Snyder, 2000) was present in the school. Teachers indicated that effective communication and collaboration with students were most effective through social networks and cloud-based software because students were always connected through the network on their devices and could respond immediately. The community of practice also allowed seamless learning between the school and home. Figure 5.16 represents the roles of community of practice networks within the school and the ICTs that enable learning to occur.

The role of the teacher was as a facilitator who connected with students both face-to-face and through networking. Figure 5.20 illustrates the different roles of the teacher as communicator, networker and collaborator which were achieved using a mixture of networking software to provide a repertoire of teaching activities in a blended learning environment. OSS access was part of the mixture of software used by teachers to facilitate and scaffold student learning. The open school network provided the pathway for teachers and students to connect and collaborate in their learning.

Student feedback indicated that teachers practised a pedagogy of care (Smith, 2012), with the open school culture enabling students to learn while supported by teacher pastoral care and access to a mix of software for learning and personalised learning pathways. Within the school, universal access to technology for learning is the backbone of the pedagogy which prepares students to learn and thrive in an increasingly-technological world (McNeal, 2016).

5.6 Discussion of Factors that Facilitate or Impede the Effective Implementation of OSS in a Senior High School

5.6.1 Factors that facilitate the implementation OSS to support learning and teaching

The senior high school is a high-performing and innovative school as assessed by the Educational Review Office (2014): "the school aims to be future-focussed and innovative" (para. 1) and "teachers have a relentless focus on achieving equitable and excellent outcomes for all students" (para. 2). The Impact Project programme in particular was recognised because it "encourages deep thinking in a creative and relevant context" (Educational Review Office, 2019, p. 2). Open source software is embedded into the school culture and, along with cloud-based and BYOD proprietary software, enables equitable student access to digital tools for learning.

The three major factors identified in this thesis for effective implementation of open source software for education and for equity and excellence of learning in a senior high school are *people*, *pedagogy* and *digital tools*.

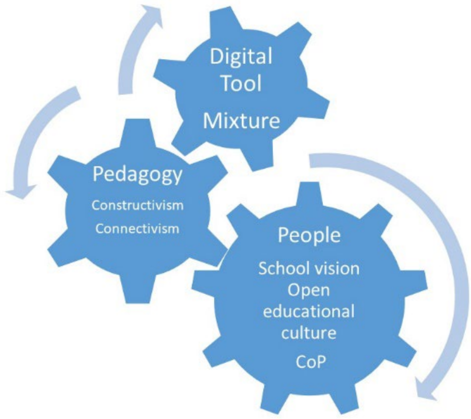

Figure 5.25 Factors that facilitate the implementation of OSS in learning and teaching in the case-study school

Figure 5.25 illustrates the connection between the three major factors identified in this thesis regarding the implementation of open source software in learning and teaching in a senior high school. The people (school stakeholders) had an open vision of learning, with the school aiming to "Nurture, Inspire, Empower students to achieve highly and be good citizens" (Educational Review Office, 2019, para. 1) and "having teachers with a relentless focus on achieving equitable outcomes and excellent outcomes for all students" (Educational Review Office, 2019, para. 2). To achieve the vision, the school developed an open school culture focussed on developing a community of practice in which an open digital tool mix was available to support learning networks both within and outside the school. Equitable access to digital tools for learning was a high priority and enabled all learners and teachers to access software/apps to scaffold and enable learning opportunities. The pedagogy was also open and student-centred with a focus on personalised project learning (Educational Review Office, 2019). Student-centred social constructivist and connectivist pedagogy allowed students and teachers to select appropriate digital tools for learning in a just-in-time manner. These digital tools were available to support learning on school desktop computers, BYOD laptops, tablets and mobile telephones. Pedagogy, not the technology, drove the choice of software. The pedagogy was driven by the school vision and the open educational school culture.

5.6.2 Model of the factors that facilitate the implementation of digital tools for learning and teaching in a senior high school

Figure 5.26 summarises the findings of this study concerning factors that facilitate the implementation of digital tools in learning and teaching in a senior high school. Section 5.6.1 established three main critical factors that contribute towards the school's community of practice: people (open education school vision); pedagogy (constructivist/connectivist); and digital tool technology (Wenger, White & Smith, 2009). OSS is part of the digital tool software mixture available to teachers and students in a school where a variety of digital tools are chosen in a just-in-time manner appropriate to the learning task or problem. Figure 5.26 illustrates the characteristics of stakeholders (people) who are committed to an open educational learning environment into which OSS fits well because it is accessible to all teachers and students and allows all students the opportunity to complete their learning tasks as evidenced in Section 4.2 and 4.3. OSS is part of the software mixture that teachers and students use to scaffold their learning, with students choosing between open source, cloud-based, proprietary and mobile software depending upon their learning needs as reported in Section 4.3.5.

The school was flexible and open in giving students the choice of software (Section 4.3.3.2). Digital tools are used to support deep learning (Fullan & Langworthy, 2014) as enablers and connectors in a social constructivist and connectivist inquiry-based learning environment (Section 4.5). Social networks and Google for Education played a major role in allowing teachers and students to connect/collaborate and receive feedback/scaffolding for learning in the school in a community of practice for which the inputs of people, pedagogy and digital tools contribute to the deep and innovative learning to nurture, empower and inspire (Section 4.5).

Sections 4.2 and 4.3 established that the stakeholders supported the choice of OSS for learning in the school was because it is adaptable for learning, sustainable, accessible for all teachers and learners, reliable and, importantly, accessible and available in a just-in-time manner for all students. The case-study research revealed that OSS is part of the digital tool mixture used in the school along with cloud-based software, proprietary software on BYO devices and mobile apps (Section 4.5.4).

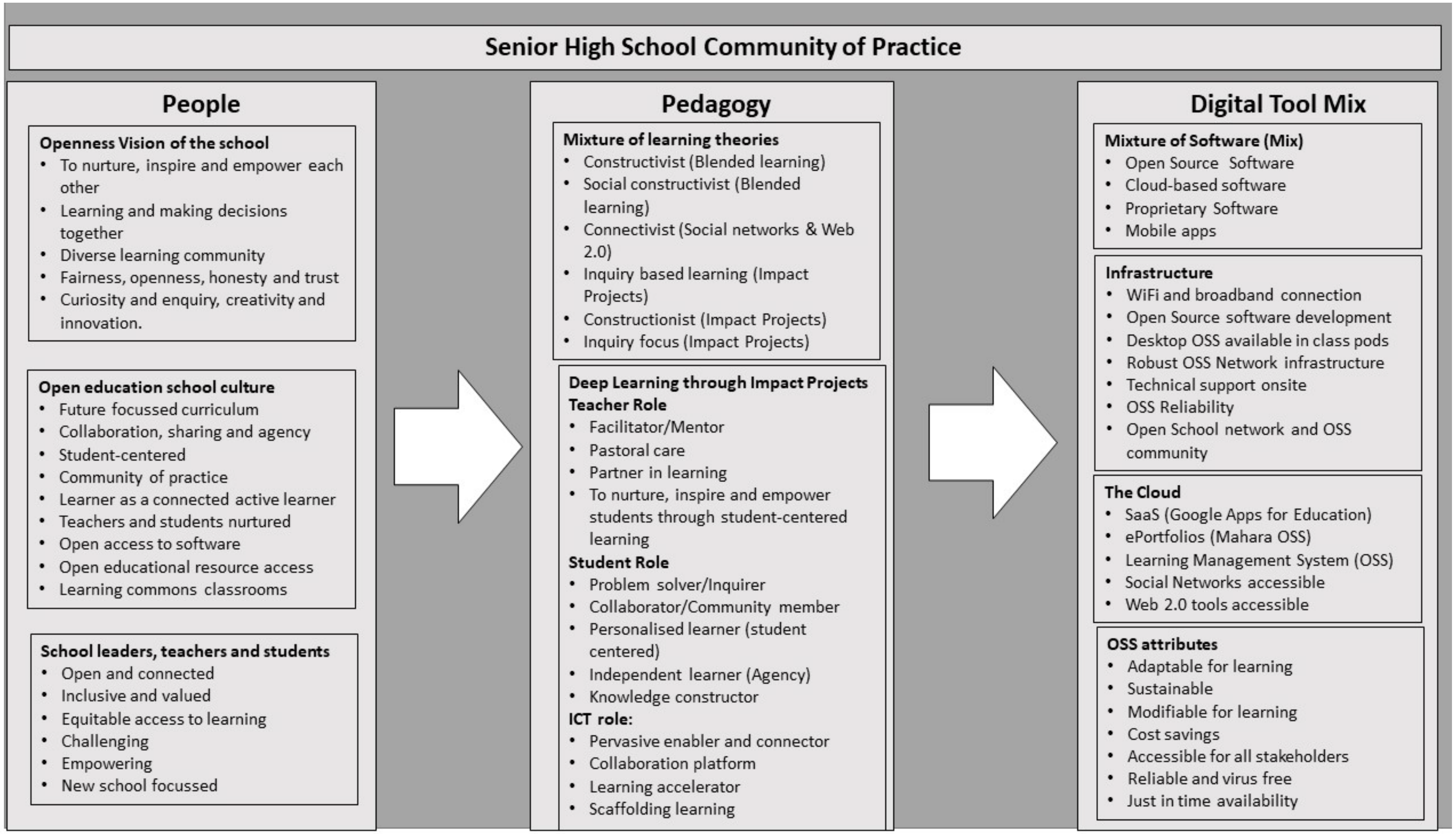

Figure 5.26 Model summarising factors for facilitating the implementation of digital tools for learning and teaching in the case-study school

In summary, the case-study research has established that a community of practice has been established in the senior high school where, from its establishment, an open educational vision was part of the school culture which included the implementation of OSS (Section 4.2.3) (Albany Senior High School (n.d.-a). The open vision of the school has impacted the choice of a social constructivist and connectivist pedagogy particularly through the impact project programme (Section 5.4.5.1 – 5.4.5.4). The teacher's role is as a facilitator/mentor and partner in learning connected with the students through cloud-based Google app software and social network groups (Section 5.4.3). The role of OSS is part of the mixture of software available to teachers and students, with students in particular making just-in-time choices of software that is appropriate to their learning needs (Section 5.4.5.2).

5.7 Significance and Implications

"To develop an approach to education that prepares 21st century students for the challenges they'll face, both now and in the future, we need to fundamentally change our ways of thinking" (Murrihy, n.d., para 7). This case study focused on a senior high school in New Zealand that aims to prepare students for the future in an open and equitable educational learning environment that includes open architecture, open network, open source software, open educational resources, and an open inquiry learning programme for all students and teachers. This school is fundamentally different in organisation and structure from most high schools in New Zealand and is recognised as successful in terms of learning and student achievement (Education Review Office, 2019).

The research contributes insights into the integration of ICTs into the learning environments of high schools, particularly where open source software is exclusively used on the school network, teacher laptops and desktop computers to support learning and teaching. A literature review in Chapter 2 identified a lack of recent research on the effectiveness of OSS for supporting learning and teaching in schools, with most past research being descriptive and failing to evaluate the impact of OSS on pedagogy and learning. This research is noteworthy for its identification of the impact of ICTs, including OSS, in scaffolding learning in a high-performing and innovative senior high school (Education Review Office, 2019).

Social constructivism (Schunk, 2012), constructionism (Martinez & Stager, 2013) and connectivist learning (Downes, 2022) underpin students' learning on the network while collaborating/communicating and receiving feedback on their learning. The school/home boundary is blurred because students learn on SaaS sites such as Google for Education and social networks. A digital mixture of software is used by students and teachers to scaffold learning whether open source, cloud-based, social networking or proprietary software is chosen to suit specific learning needs or tasks. In particular, social networking was used for communication and collaboration amongst students in that they always had Facebook messaging activated on their mobile telephones. OSS had a critical role in the school as a secure and reliable school network to keep teachers and students constantly connected and learning over the network. Specialist OSS had a role in providing access to all students to specialised software in curriculum subjects. In contrast to some other schools that block student access to social networking sites, students at the case-study school collaborated and gained feedback on learning.

In this study, it was established that teachers and students in the school used a mixture of software to scaffold their learning and that the school networks enabled students and teachers to use a mix of cloud-based, open source and proprietary software to support their learning. The study also established the importance of BYOD and mobile telephones in allowing students the freedom to use cloud-based software and social networks to create, collaborate and receive feedback on learning. The combination of a software mixture and the power of BYOD devices/mobile telephones has implications for other schools using pedagogy and digital tools to scaffold student learning and facilitate a school and learning environment that meet students' needs now and into the future.

From a practical point of view, this research established that it is possible for a school to install and run an open source network and provide teacher laptops and student computer workstations with Edubuntu OSS. The advantages of open source software identified in this thesis include equitable access, sustainability, bridging the digital divide, security, opening up education and cost saving. The recent Covid-19 lockdown has increased awareness of the digital divide and lack of access for many students to hardware, software and internet connectivity (New Zealand Government, 2021). Older laptops running on Linux software would help lower-income families to provide devices to help students to study at home (Wiltshire, 2020). This study also suggests that scaffolding is needed for both teachers and students in order to use the open source software successfully, and that student participation in open source deployment in a school gives students more ownership of OSS (Reisinger, 2016).

5.8 Limitations of Research

It is acknowledged that, prior to and during my research, a number of limitations were encountered. This section considers these limitations and the subsequent decisions and actions that were taken to minimise their effect on my study.

Creswell (2003, p. 182) states that "qualitative research is fundamentally interpretive" in that the researcher filters and discusses the data through a personal lens. I acknowledge that my constructivist research position, together with my experience as a primary-school teacher and tertiary lecturer with a background in the integration of ICTs into teaching practice, could have influenced my interpretation and discussion of results.

Because I am not associated with the senior high school, I was reliant on the Deputy Principal to choose students for the focus groups and web survey. For gender balance, five female and five male students took part in each year-level focus group, whereas 93 students out of the 700 voluntarily participated in the web survey. According to the literature, online surveys are generally less likely to gain high response rates than paper surveys (Nulty, 2008). The students chosen were therefore neither random nor representative, but they were those who accepted the invitation to participate in focus groups and had returned signed permission slips.

As noted in Section 3.6.5, observations were a limited part of the data gathering process for time constraints and intrusion into the classroom teaching. For future research, it is recommended that the researcher observes classroom use of OSS during the student learning activities.

The ten participating teachers were those who indicated to the Deputy Principal that they were willing to be involved in a face-to-face interview, with five females and five males for gender balance. All the senior management personnel participated in the surveys.

Because the data for my case study were collected in 2013–2014, I could not take into account the many changes that have occurred since then in the use of computers for learning (e.g. online learning associated with the Covid-19 pandemic and the higher speed of schools' broadband). Therefore, findings based on my 2013–2014 data might not be generalisable to schools in 2022.

Because the case-study school is unique in New Zealand in its use of OSS on the school computers, there are no other studies with which to compare results and conclusions. Willis (2014, p. 5) considers that an unavoidable criticism of a single case study is "the issue of external validity and generalisability" and King et al. (1994, p. 212) recommends that "in all social science research and all prediction, it is important that we be as explicit as possible about the degree of uncertainty that accompanies out prediction". No similar research was located during a worldwide literature review, with the only research located being descriptive and unrelated to effective learning and teaching. Further research into similar schools using OSS for learning and teaching would enable triangulation with results and conclusions from this research.

5.9 Recommendations for Future Research

This research has contributed to understanding of the implementation of open source software for learning and teaching in a senior high school. As the research progressed, issues and suggested areas for future studies surfaced:

1. Students used a mixture of software on BYOD devices to scaffold their learning both in school and outside school. Therefore, it is recommended that further research is conducted into high-school students' use of a mix of software, particularly cloud-based software, applications and social networking on BYOD devices, to scaffold their learning and develop a community of practice.
2. Because very few high schools use OSS exclusively in administration and teaching, further research is needed to identify advantages and barriers in its implementation in high schools that currently are using proprietary software.
3. With this study revealing that the students learnt through a connectivist pedagogy with high use of social networks and cloud-based software, further research is needed to illuminate the significance of social networks and cloud-based

software for high school students' learning. What are the characteristics of school cultures that encourage and nurture connectivist learning?

4. Because this research identified that the case-study school's culture was built upon innovative open educational principles, further research is recommended into the role of technology in supporting open education and its effect on learning outcomes in other schools with an open educational philosophy.
5. The Impact Project programme within the case-study school was identified as a successful inquiry-based pedagogy which was scaffolded by technology. Further research is recommended on this programme, the role of teacher, the role of technology and the programme's success for students' learning outcomes.
6. Because OSS is free of charge and therefore has the potential to promote equity among schools/students of different socioeconomic statuses, it is recommended that equity be included as a major research theme/question in future studies.
7. To triangulate the results of this research, another case study of a high school that exclusively uses open source software for learning and teaching is recommended. The school would also need to include an open educational philosophy component in its school culture.

5.10 Conclusion

My study of OSS in education is significant in view of the limited number of past studies of its effectiveness in supporting learning in a high-performing and innovative school as identified by the Education Review Office (2014). This research contributes understanding of the effectiveness of using OSS in a school with an open educational learning setting that provides equitable access to specialist software for learning. The research confirmed the importance of digital tools for scaffolding learning in a school that provides a mixture of software for students, as well as highlighting the increasing importance of cloud-based software and social networking to support social-constructivist and connectivist learning on a network for students using BYOD devices.

The combination of people (learning vision and open educational culture), pedagogy (constructivism and connectivism to accompany learners, nurture and bring learning to life) and digital tools (choice, access and a mix of software available for learning) contributed to a community of practice in the senior high school. All stakeholders interviewed were passionate about both learning and the open education environment in which learners were valued and nurtured. Open source software is a component of a software mixture which allows equitable access, sustainability, adaptability and cost saving in a school where digital tools support people and pedagogy.

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APPENDIX A

STUDENT ONLINE SURVEY

OPEN SOURCE SOFTWARE AT CASE-STUDY SCHOOL

Survey: Open Source Software at ****** Senior High School

Survey: Open Source Software at **** Senior High School**

1. This survey is part of a Doctoral research project conducted by Malcolm Roberts of the Waikato Institute of Technology. The survey is designed to gain an understanding into how students at Albany Senior High School use Open Source Software as part of their learning. Your input into this survey is highly valued and thank you for participating in this survey.
   Yes I understand this:
2. 2. Summary: Survey is confidential; Your responses are anonymous; no names are recorded. To read the information form about this survey: click this link:
   https://docs.google.com/document/d/156rfCDWQVptht9_e5MGgY_4cknUiuPUhb3aavr2zsII/e
   Yes: I have the information Sheet and agree:
3. If you complete this web survey (no more than 15 min to complete) you will go into the draw to win one of five double Hoyts Movie Vouchers. You need to enter your School ID. Five lucky winners will be drawn and notified by the Deputy Principal.
4. What is your year level? (Year 11, Year 12 or Year 13)
5. What is your gender? (Male, Female)
6. In one sentence define ‘open source software’.
7. Open source software is available on all the Albany Senior High Computers. What experience if any, did you have using open source software before coming to Albany Senior High?
8. What computer operating system to you use at home?
   A) Microsoft Windows
   B) Apple Mac
   C) Open Source (Unbuntu, Debian etc…)
   D) No home computer
9. How would you rate the ease of use of the open source software (on computer desktops) on the Senior High computers?
   A) Easy

B) Average

C) Hard

10. What do you like about using open source software (e.g. Libre Office, GIMP. Audacity) at the Senior High school?
11. What don't you like about using open source software on the Senior High computers?
12. Which open source software available on the computers at the Senior High do you like using? Why?
13. What was your Impact Project for last term?
14. Which computer software did you use to support your project?
15. How does the availability of open source software impact on your learning at the Senior High?
16. In your opinion why does the Senior High use open source software?
17. What are the advantages of Google Docs?
18. How does Google Docs support your learning?
19. How do you find the use of ePortfolio software at the school?
20. How does the ePortfolio software help your learning?
21. How do you find the use of the intranet software (Moodle) at the school?
22. How does the intranet software help your learning?
23. In what ways do the teachers use open source software?
24. In what ways does open source software contribute to your learning?
25. Will you use open source software when you leave school?
26. Do you bring your own device (e.g. Laptop/Tablet) to school to help with your learning?
27. What type of device do you bring to school?

    A) Smartphone

    B) Laptop

    C) Tablet (iPad, iPod or Android Tablet)

    D) None
28. Do you use Facebook as part of your learning at school?
29. Any other comments?

APPENDIX B

SAMPLE OF INTERVIEW QUESTIONS STUDENTS AND TEACHERS

Focus Group Questions for Students

Focus Group Questionnaire: Year 11

March Interview

Questions:

1. If someone asked you – what is open source software, what would you say to them?
2. Before coming to Albany Senior High School what previous experience had you had with open source software?
3. How did you find using open source software at School at the start of this year for the first time?
4. What are the advantages in using open source software in your learning at school?
5. What are some challenges/problems you have had in using open source software at school?
6. Are there any specific learning activities where you feel the use of open source software has made a difference? Can you describe the activity and how it has made a difference?
7. Do you use open source software at home? If so, does it help you with your learning at school? Is there any specific software that you use? What do you use the OSS for?
8. Does the use of open source software contribute to learning in groups? Describe any collaborative activities using open source software.
9. If someone asked you, what is the most important advantage of using open source software at school, what would you say to them?
10. Thank you for your participation in this focus group and I look forward to our next session mid-year.

Focus Group Questionnaire: Year 11

October Interview

Questions:

1. What is open source software? Can you tell me a definition?
2. How do you find the open source software that is loaded onto the computers at this school? Were there any problems adapting to the use of the software this year?
3. What are the advantages in using open source software in your learning at school? What have you found this year?
4. What are some challenges/problems you have had in using open source software at school so far this year?
5. What is your project for Impact Wednesday? What software have you used to help you with your project?
6. Are there any learning activities in class where you feel the use of open source software has made a difference? Can you describe the activity and how it has made a difference?
7. Have you used open source software at home? If so, does it help you with your learning at school? Is there any specific software that you use? What do you use the OSS for?
8. Does the use of open source software contribute to learning with other students and feedback from teachers? Describe any collaborative activities using open source software.
9. Have you used the ePortfolio software? How have you found the use of the software?
10. Have you found the intranet software (Moodle) useful?
11. If someone asked you, what is the most important advantage of using open source software at school, what would you say to them?
12. Any issues in emailing files between your home computer and school computers?
13. Have you used Facebook for school during the year? What is the purpose and how does it help with your studies?
14. Thank you for your participation in this focus group.

Focus Group Questionnaire: Year 12-13

April Interview

Questions:

1. If someone asked you – what is open source software, what would you say to them?
2. Before coming to Albany Senior High School what previous experience had you had with open source software?
3. How did you find using open source software at School at the start of this year for the first time?
4. What are the advantages in using open source software in your learning at school?
5. What are some challenges/problems you have had in using open source software at school?
6. Are there any specific learning activities where you feel the use of open source software has made a difference? Can you describe the activity and how it has made a difference?
7. Moodle is open source software: How do you use Moodle at School?
8. Do you use open source software at home? If so, does it help you with your learning at school? Is there any specific software that you use? What do you use the OSS for?
9. Does the use of open source software contribute to learning in groups? Describe any collaborative activities using open source software.
10. If someone asked you, what is the most important advantage of using open source software at school, what would you say to them?
11. Thank you for your participation in this focus group.

Senior Management Interview Questions

1. You have met a colleague from another school: she inquires about the meaning of open source software? How would you respond?
2. Your colleague inquires, how does the open source software philosophy fit with your School vision?
3. Having explained the meaning of open source software: she asks: why are you using open source software in your school? What benefits would you mention?
4. How does is classroom pedagogy used by teachers enhanced by the use of Open source software?
5. You colleague then replies I am interested to know: can you give me examples of ways open source software is used in your school to support learning?
6. Your colleague then replies: that is very interesting: What about the problems, challenges, and difficulties in using open source software in your school?
7. What if you colleague asks: Don't most businesses use Microsoft Office: will your students be penalised when they leave school?
8. When you joined the school were you familiar with open source software? If needed what professional development did you take to get up to speed with using open source?
9. Colleague then asks: what are the main benefits to the students in using open source software to support their learning? What would you say?
10. What advice would you give to your colleague if they showed an interest in implementing open source software throughout their classroom/school?
11. Where do you see your school going with open source software in the future?
12. What impact does open source software have on the individual students regarding the school/home context? Any impact on your personal use of software at home?
13. Is there any ways in which open source software contributes towards developing a community of practice at the school in terms of the teachers, students or both?

Classroom Teachers Interview Questions

1. You have met a colleague from another school: she inquires about the meaning of open source software? How would you respond?
2. Having explained the meaning of open source software: she asks: why are you using open source software in your school? What benefits would you mention?
3. You colleague then replies I am interested to know: can you give me three different examples of ways open source software is used in your classroom to support learning?
4. Your colleague then replies: that is very interesting: What about the problems, challenges, and difficulties in using open source software in your classroom?
5. What if you colleague asks: Don't most businesses use Microsoft Office: will your students be penalised when they leave school?
6. Does open source support your classroom pedagogy? If so how?
7. When you joined the school were you familiar with open source software? If needed what professional development did you take to get up to speed with using open source?
8. Colleague then asks: what are the main benefits to the students in using open source software to support their learning? What would you say?
9. What advice would you give to your colleague if they showed an interest in implementing open source software throughout their classroom/school?
10. Where do you see your classroom/school going with open source software in the future?
11. What impact does open source software have on the individual students regarding the school/home context? Any impact on your personal use of software at home?
12. Is there any ways in which open source software contributes towards developing a community of practice at the school in terms of the teachers, students or both?

APPENDIX C

PARTICIPATION INFORMATION SHEET

Participant Information Sheet

Board of Trustees, Senior Management, Teachers and Students

Date Information Sheet Produced:

14 March 2013

Project Title:

The main critical success factors for the implementation of open source software supporting learning and teaching in a New Zealand High School

An Invitation

From Malcolm Roberts, Doctor of Philosophy candidate at Curtin University, Perth Australia.

You are invited to participate in a research project at the Albany Senior High School. The aim of the project is to investigate the critical success factors for the implementation of a 21st Century Senior High School in New Zealand which utilises open source software for learning and teaching.

Your participation in the research will be voluntary and you will be able to withdraw from the project at any time. In this event, any information that you have provided will not be used.

What is the purpose of this research?

The purpose of this research is to investigate the use of open source software within the high school context. Very few schools use open source software and it is important to understand the advantages and disadvantages in relation to teaching and learning. Your views on open source software are very important and will be used to analyse how the software is being used in the school. Results taken from this research will inform other schools about the value of open source software and factors they need to take into consideration when using open source software.

The findings from the research will be shared with others through presentations, discussions, publications and reports.

How was I identified and why am I being invited to participate in this research?

You are being asked to participate in this research as you are a member of the Board of Trustees at Albany Senior High and your views on open source software in the educational context are important. As part of the governance of Albany Senior High I am interested in your views and opinions on Open Source Software.

What will happen in this research?

If you agree, you will be asked to fill in a very short questionnaire. I will ask if you have come across the term Open Source Software. If the answer is yes, I am interested in what Open Source Software means to you, the benefits of Open Source Software for the school and how does the Board of Trustees support open source software in the school.

What are the discomforts and risks?

It is unlikely that you will experience any discomforts or risks as a participant.

How will these discomforts and risks be alleviated?

If you do find any questions make you feel uncomfortable, you can choose to not respond to them.

What are the benefits?

The findings from the research are primarily intended to improve the learning opportunities and experiences for current and future teachers at Albany Senior High. You may also find that your participation helps you reflect on the use of open source software within the school. Students and researchers at other universities may also benefit from the information that you contribute to the research. There is a lack of research into the use of open source software in high school education and this thesis will make a worthwhile contribution to the research environment.

How will my privacy be protected?

If you choose to participate in the research you will be asked to sign a consent form that will be stored in a secure location by Malcolm Roberts the researcher. Your responses to the interview will be identified by a pseudonym "BOT 1" etc… No information which could identify participants will be included in any presentations or publications. Confidentiality concerning the identity of participants will be assured. At the completion of the study all data will be held in a secure ethics storage facility and will be destroyed after five years.

What are the costs of participating in this research?

The only cost associated with your participation is time.

What opportunity do I have to consider & agree to this invitation?

During the presentation about this project you have the opportunity to ask questions and sign a consent form if you wish.

Will I receive feedback on the results of this research?

A summary of the findings will be available to Albany Senior High. Hamish Chalmers the Deputy Principal will have a copy of the complete thesis which will be available to all students and teachers.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the researcher: Malcolm Roberts. Email: malcolm.roberts@wintec.ac.nz

You should also contact Malcolm Roberts if you wish to withdraw from the project.

Whom do I contact for further information about this research?

Researcher Contact Details:

If you would like further information about the project, please contact:

Malcolm Roberts

Program Manager

Graduate Diploma of Information Technology in Education

School of Education

Waikato Institute of Technology

Hamilton

Ph: 07 834 8800 ext 8524

Email: malcolm.roberts@wintec.ac.nz

Approved by the Curtin University Human Research Ethics Committee on 1st March, 2013, Reference number *SMEC-08-12*

PARTICIPANT CONSENT FORM

Curtin University

Science and Mathematics Education Centre

Participant Information Sheet

My name is Malcolm Roberts. I am currently completing a piece of research for my Doctor of Philosophy at Curtin University.

Purpose of Research

I am investigating the critical success factors involved in the implementation of open source software in a New Zealand High School.

Your Role

I am interested in finding out how open source software is used by both students and teachers in a High School.

I would like to find out what factors are involved in using open source software for learning and teaching.

I will ask you your opinion about the use of open source software in a focus group.

The focus group process will take approximately 30 minutes.

Consent to Participate

Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities. When you have signed the consent form I will assume that you have agreed to participate and allow me to use your data in this research.

Confidentiality

The information you provide will be kept separate from your personal details, and only myself and my supervisor will only have access to this. The interview transcript will not have your name or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further Information

This research has been reviewed and given approval by Curtin University Human Research Ethics Committee (Approval Number SMEC-08-12). If you would like further information about the study, please feel free to contact me on 07 834 8800 ext 8524 or by email malcolm.roberts@wintec.ac.nz . Alternatively, you can contact my supervisor Darrell Fisher at D.fisher@curtin.edu.au .

Thank you very much for your involvement in this research.

Curtin University

CONSENT FORM

• I understand the purpose and procedures of the study.

• I have been provided with the participation information sheet.

• I understand that the procedure itself may not benefit me.

• I understand that my involvement is voluntary and I can withdraw at any time without problem.

• I understand that no personal identifying information like my name and address will be used in any published materials.

• I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.

• I have been given the opportunity to ask questions about this research.

• I agree to participate in the study outlined to me.

Name: ____

Signature: ____

Date: ______________________

Caregiver____

Signature____

Date:__________________________

Your participation is greatly appreciated.

APPENDIX D

CURTIN UNIVERSITY ETHICS APPROVAL

Curtin University

Office of Research and Development
Human Research Ethics Committee
Telephone 9266 2784
Facsimile 9266 3793
Email hrec@curtin.edu.au

Memorandum

To	Malcolm Roberts, SMEC
From	Pauline Howat, Administrator, Human Research Ethics, Science and Mathematics Education Centre
Subject	PROTOCOL APPROVAL - EXTENSION
Date	1 March 2013
Copy	Darrell Fisher, SMEC

Thank you for keeping us informed of the progress of your research. The Human Research Ethics Committee acknowledges receipt of your Form B progress report for the project "The main critical success factors for the implementation of open source software in a New Zealand high school."
Approval for this project is extended for the year to **23rd February 2014**.
Your approval number remains **SMEC-08-12**. Please quote this number in any further correspondence regarding this project.
Please note: An application for renewal may be made with a Form B three years running, after which a new application form (Form A), providing comprehensive details, must be submitted.
Thank you.

Pauline

PAULINE HOWAT
Administrator
Human Research Ethics
Science and Mathematics Education Centre

J:\SAE\SMEC\office\Pauline\ETH