

Technology in the classroom: Exploring  
the experience of secondary students  
using activity theory

by

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Ko Rangi

E tipu, e rea, mo nga ra o tou ao, ko to ringa ki nga rakau a te Pakeha hei ara mo te tinana, ko to ngakau ki nga taonga a o tipuna Māori hei tikitiki mo to mahuna, a ko to wairua ki to Atua, nana nei nga mea katoa.

Sir Apirana Ngata, 1949

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# Technology in the classroom: Exploring the experience of secondary students using activity theory

## Abstract

Technology is an integral part of life in the senior secondary school classroom. The multiple and complex ways in which economic, social and political discourse and activity drive digital technology into the classroom are often framed in terms of the ‘transformation of education’ and ‘21<sup>st</sup> century skills’, configuring values and aspirations with technology.

This thesis explores what digital technology means in the classroom. It moves from the ‘state-of-the-art’ and ‘state-of-the-possible’ to the ‘state-of-the-actual’; from the impact of singular IT artefacts to the experience of the students. It addresses the questions, what is the technology artefact that the students are using in the classroom? and, how do students engage with the technology artefact and the information artefact in the classroom?

Four secondary schools in medium- to high-income areas of New Zealand participated in this qualitative study. Activity theory informed the research design and case analysis. Critical realism was used, via abductive and retroductive modes of inference, to make sense of the data and identify the structures and generative mechanisms underlying the use of technology in the classroom.

To make sense of how the students use the technology in the classroom this thesis presupposes that learning is a function of information, and information is not coterminous with information technology. The students’ learning actions can be instrumental, cognitive or axiological, and the activity can be mediated by technology. The use of technology is initially rooted in practical operations. This thesis sets out to revindicate a wider understanding of the technology/tool in activity theory by revisiting the concept of *functional organs*. This conceptualisation reorients perspectives

on processuality, emergence and causation to reach an understanding of the student and the technology working in unison as an *organisation*, which allows different possibilities of operations, of actions and of relationships.

The findings of this study are that the technology in the classroom is *ubiquitous spatially*, almost every student has access to a device, software and the internet, and *temporally*, most students have a device to hand all the time. The technology can have a *multiplicity of causes*, the same effect can be performed with different combinations of technology, and a *plurality of effects*, the same combination of hardware and software can be used to perform different actions. Senior secondary students are responsible for *selecting* and *structuring* a combination of hardware and software to achieve the object of their activity.

This structuring is generally seamless, and without tension or contradiction when the object of the activity is instrumental, or when the information items required by the student are simple and linear, such as examples of concepts or contextual information. On the other hand, when the students' experiences of the information are within activities that work with complex principles, generalisations or procedures then the technology needs to allow that possibility of action. Some specialist software does allow that possibility, and enables the student to engage deeply with the information. Conversely, some technology can impact the students' practices if the critical analysis required of the students is not supported by the analytical processes of the technology, which may encourage students to follow linear rather than dialectical or dialogical engagement with the information.

This thesis concludes that the students are active in structuring their learning through creating *organisations* of themselves, the technology and the information as an emergent information system to achieve the goal of the learning action, which is embedded in the wider motivation of the learning activity.

Keywords: Activity theory, critical realism, education, hylomorphism, form, matter, emergence, functional organs, technology artefact

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## Glossary and acronyms

			<b>Section</b>
Boards of trustees		Boards of trustees are the governing bodies of school.	1.1
BYOD	Bring your own device	BYOD is the practice of the student bringing their own laptop or tablet to school.	1.1
Crown-owned company		Crown-owned companies are generally established by the Crown to further certain policy objectives, eg, Network for Learning, Crown Fibre Holdings Ltd.	2.1.3
LMS	Learning management system	A learning management system is a software application for the management and delivery of educational courses.	2.4.2
Multiplicity		In critical realism in an open system there can be a ‘multiplicity of causes’ which result in the same effect.	1.2
NCEA	National Certificate of Educational Achievement	Students learning the national curriculum work towards these certificates.	Appendix 3
Plurality		In critical realism in an open system the event will normally be complex, and there can be a ‘plurality of effects’.	1.2
Private school		Schools mostly funded through school fees and may follow the national curriculum.	Appendix 3
RBI	Rural Broadband Initiative	The RBI would provide the rural equivalent of the UFB, to improve broadband connectivity to rural schools, health providers, businesses, farms and households.	Chapter 1

			<b>Section</b>
Select Committee		Select Committees comprise Members of Parliament from several political parties to consider topics that Parliament needs more information on and recommendations about, eg, proposed laws, and government spending.	1.1
SNUP	School Network Upgrade Project	SNUP is a government programme to subsidise the wiring and switching through schools in order to take advantage of the UFB to schools.	1.1
State school		Government owned and funded state schools which teach the national curriculum.	Appendix 3
State-integrated school		Schools with a special character, often religious, partly funded by government, and teach the national curriculum.	Appendix 3
Tool		Tool is a term from activity theory, which comprises both the physical tool and the psychological sign.	3.2.2.1
UFB	Ultra-Fast Broadband initiative	The government committed to the UFB initiative in 2011, at a final cost of over \$2 billion. The intention was that fibre-optic cable would be made available to 75 percent of New Zealanders over the next ten years, with an emphasis on businesses, schools, health services and greenfield developments.	Chapter 1
WSNUP	Wireless School Network Upgrade Project	WSNUP is a government programme which focuses on enabling wireless technology in schools, and is an upgrade to SNUP.	2.1.3



## Chapter 1 Introduction and aims

In 2011 the New Zealand Government committed to spending up to \$1.5 billion to upgrade the (privatised) telecommunications infrastructure from a copper network to a fibre optic cable network capable of supplying ultrafast broadband. The Ultra-Fast Broadband (UFB) initiative would cover 75% of New Zealanders over the next ten years, and the Rural Broadband Initiative (RBI) would provide broadband connectivity to the rural community. New Zealand is a small country, and the project, at approximately one eighth of the national deficit at the time, represented a substantial investment. By 2017 that spend had increased to over \$2 billion (Ministry of Business Innovation and Employment, 2017). Under the National Infrastructure Plan the Government stated that the emphasis of the UFB was on making fibre-optic cable available to businesses, schools, health services and greenfield developments, and the RBI would provide connectivity to rural schools, health providers, businesses, farms and households (National Infrastructure Unit, 2011).

Under both the UFB and RBI the Government prioritised making the fibre-optic cable network available to schools. In June 2011 Steven Joyce, the Minister for Communication and Information Technology, was asked a Parliamentary question, “What benefits will ultra-fast broadband services

bring to education in New Zealand?” The Minister answered (*Hansard*, 2011),

Ultra-fast broadband to schools will transform the education system, making New Zealand school networks among the most wired in the world. It will enable schools to significantly enhance teaching practices, improve student engagement, and lift achievement. More than a third of all State and State-integrated schools will be fibre-ready by the end of this year, with all State and State-integrated schools given a broadband boost by 2016. This technology means that students anywhere in New Zealand can have instant access to the best teachers and online resources from anywhere in the world, and this Government is proud of its investment in this network for education.

A number of statements here stand further investigation. How does connecting a school to fibre enhance teaching practices? Is there a direct, measurable relationship between faster access to the internet and improved student engagement and achievement? Are the best teachers online? Is investment in a fibre network the best way to achieve these education goals? These questions propelled my doctoral journey by prompting me to ask, is there evidence to support these statements?

Information and communication technologies in schools have been attributed with the power to directly improve the learning outcomes of students, or to change institutionalised education by bringing it into the 21<sup>st</sup> century, or to empower youth through knowledge, access and skills. These approaches all invite a particular paradigm: an evaluation of the advantages and disadvantages of technology, which tends to focus on issues of productivity, efficiency and control. These foci address concerns of the educator, the technology provider or the policy maker; the students' experience and the choices they make are often overlooked.



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This is a problem because focusing on the technology can reinforce the very assumptions that marginalise the experiences of the students. For example, emphasising the ‘state-of-the-art’ technology reinforces the idea that non-use of the feature is due to the lack of skills of the student and often posits a deficit model of the student that can only be remedied by using a particular technology. Alternatively, focusing on barriers and opportunities for teachers to introduce the technology and provide ‘state-of-the-possible’ classrooms reduces the agency of the students. Both of these approaches overlook the ‘state-of-the-actual’, the many ways that students use the technology in their everyday learning. This thesis positions the research away from evaluation and towards understanding, by asking “how do students use technology in their everyday experience?”

## 1.1 Research aims

While this thesis’ initial motivation was the rollout of fast fibre under the UFB it was found that this could not be the technological basis of the research. Due to commercial sensitivity the extent of the fibre network rollout was unclear, and some schools were provided with ultrafast broadband over copper cable networks during the period of this study. The materiality of the technology (fibre) became less relevant than the form and function (ultrafast broadband) of the technology. Also, the broadband technology could not be considered alone without supporting connectivity technology such as wireless access points, hardware in the form of laptops, desktops and phones, and software, which ranged from education specific software to general software such as browsers and search engines. The students experience learning in an open system, which could not be closed to make broadband a unique variable, so all of the technology used by the student had to be considered as part of the technology artefact. And even when there were multiple configurations of technology bringing fibre or ultrafast broadband to a school not all of the students were able to access it, so the study could not be based upon an essentialist view of the technology.

New Zealand has never had an explicit, binding policy on what technology should be used in the classroom, and leaves the choice of technology, and some of the burden, to the individual schools. While schools frequently provide access to computers to the students, across the nation many schools have embraced the practice of Bring Your Own Device (BYOD), where the students and parents supply a device which is connected to the school network. This means that the Government is not the only stakeholder of technology in the classroom. As part of the Government spend under the UFB the provider needs to supply fibre to the State or State-integrated school. The school needs to upgrade its wiring and switching through the School Network Upgrade Project (SNUP), which is paid for by the Ministry of Education and the school. The school pays for the wireless access points, VOIP, and any data that it uses. The school pays for the desktops, laptops or tablets, software and any learning management systems that the school uses. For Private schools the provider will lay fibre to the street, and the school must pay for wiring, switching, and everything else. Private schools require the student to buy, insure and service their own devices under BYOD, and State and State-integrated schools are increasingly adopting this practice. With all these different stakeholders there are multiple purposes, constraints and tensions at work which impact on what technology is brought into the classroom.

In addition, technology is ever changing and never reaches a steady state, so the actual technology the students encounter in the classroom is different between schools, between classes and between students. The technology, and the configuration of that technology in the classroom cannot be assumed. The first aim of the research then was to identify the technology that the students use in the classroom.

Even once the technology in the classroom was identified it was relevant to consider the technology in the context of the students' education and ask *how* is the technology used by the students and the teachers. As the NZ Ministry of Education literature review on e-learning and schools stated,

“the provision of a tool isn’t enough, if people don’t know what it’s for or how to use it” (Wright, 2010, p. ii).

The Government convened the Education and Science Select Committee to inquire into 21st century learning environments and digital literacy. The Committee recommended that the Government “...provid[e] the leadership to deliver both digital capability and 21st century learning environments” (Education and Science Committee, 2012, p. 39). Ultimately the government organs centralised the technical aspects of the network services, leaving the “boards of trustees<sup>1</sup>, principals, and teachers free to focus on the use of the technology to deliver 21st century learning” (2012, p. 36), leaving a “lack of clear and consistent messages from the ministry on digital learning” (2012, p. 38).

Influence on technology in the classroom is not just from government or academia. This is a topic that has wider public interest. It is reported in the popular press, from newspaper stories that give opinions on schools that either adopt or decline to adopt bring your own device policies (Jones, 2015; McPhee, 2015; Stock, 2019), and in blogs of technology companies with emotive titles such as “10 reasons today’s students NEED technology in the classroom” (Mareco, 2017). Parents’ concerns range from statements that children need to know how to use the technology otherwise they will be left behind (Private conversation, 2017), to being concerned that students are spending too much time playing games, that their handwriting is suffering, and that parents are feeling alienated because they can no longer see what their children are doing which they could when children worked in books or on posters (Bate, MacNish, & Males, 2012).

While debate rages on in the popular press and academic research, with little guidance from government and conflicting pressure from parents, the teachers and students are figuring out when and how to use the technology

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<sup>1</sup> Boards of trustees are the governing bodies of schools, similar in function to company boards.

that is available to them in their learning. The second aim of this thesis is to explore the experience of students in the classroom, and to draw insights from how students, technology and information *interact* when students learn with technology in the classroom.

The purpose of this thesis is not to instantiate, modify or extend existing theory (Grover & Lyytinen, 2015), but to attempt to capture the nuances and contingencies of the everyday experiences of the students. Through exploring these experienced events the thesis aims to contribute a systematic approach to understanding the complex interactions between the student, the technology and the information. The focus of this research is to move away from the pros and cons of the technology and from the normative statements of what students should and should not be doing, to finding out what the students choose to do and not do with the technology in the classroom. This entails asking exploratory questions that are not predicated upon theory or gaps arising from the literature. The research questions that guide the thesis are:

**RQ1: What is the technology artefact that the students are using in the classroom?**

**RQ2: How do students engage with the technology artefact and the information artefact in the classroom?**

These questions are intended to explore a range of learning actions and capture rich data, to enable this thesis to identify the generative, causal mechanisms that underlie the students' use of technology in the classroom.

## 1.2 Research approach

The research aims then lead to investigating the students' learning activities in the classroom. The classroom can be characterised as an open, recursive, and semiotic system (Biesta, 2015b, p. 16). The classroom is open because it interacts with its environment, and it cannot be closed in this study to make the research experimental. The classroom is recursive because every

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day the learning builds upon what has gone before, and the system evolves through the agency of the teachers and the students. The classroom is semiotic because it relies on communication, interpretation, and making meaning of information.

This thesis uses a three-pronged approach *as a response* to the openness of the system and the research questions. The first is to embed the research into the discipline of information systems. An information system can also be open, recursive and semiotic, and this thesis will use the conceptualisation of an *information systems artefact* as an emergent entity comprising a *technology artefact*, a *social artefact* and an *information artefact* (Lee, Thomas, & Baskerville, 2015). The social artefact will be defined as senior secondary students, and the information artefact will be defined as the typology of information items developed by Nuthall (1999, 2001b). The first question, to identify the technology in the classroom, is framed in information systems as identifying the technology artefact. The second question exploring how students, technology and information interact is framed as identifying the emergence of the information systems artefact.

The second prong is using the philosophy of critical realism (Bhaskar, 1975, 1986, 1993). The critical realist methodological model of explanation was developed to guide research in an open system, and for each experienced event the researcher assumes that there may be a multiplicity of causes and a plurality of effects. This openness precludes making certain and precise predictions, which is core to deductive and inductive reasoning. Central to the methodological model of explanation is *retroduction* as a mode of inference, where the researcher asks *What must be the case for this event to be possible?* (Bhaskar, 1975, p. 29) to identify the underlying mechanisms which generate the event.

The third prong is activity theory (Engeström, 2015; Leontiev, 1978; Vygotsky, 1978). Activity theory recognises that learning and cognition are material and practical processes that arise and develop in the real world,

through purposeful, goal-directed activity. In the 90 years since Vygotsky published *Tool and symbol in children's development* many researchers have contributed to building a cohesive yet broad understanding of cultural historical activity theory. This thesis will use Engeström's activity theory triangle (2015) as a framework to explicate how purposeful human activity is mediated by signs and tools, and how rules, the community and the division of labour affect that activity. The activity theory term *tool* is equated with the information systems term technology artefact, while *sign* is equated with the information artefact.

Students who are in the same class, and who are doing the same thing, have very different learning experiences (Nuthall, 2007). Dewey identified the unpredictable nature of learning when he stated (1938, p. 48), “[p]erhaps the greatest of all pedagogical fallacies is the notion that a person learns only the particular thing [they are] studying at the time.” Given that each student's engagement with technology will be different, and each teacher's use of technology in the classroom will be different, this thesis will present the data from multiple case studies. The analysis of this rich data takes a non-traditional approach, which is outlined in the next section.

### 1.3 Thesis structure

#### 1.3.1 Non-traditional research approach

The thesis does not follow the traditional structure. Grover and Lyytinen (2015) identify the hypothetico-deductive model as the basis for the dominant script for research in information systems, and suggest that the institutionalized patterns of creating knowledge, and processing and evaluating those knowledge products, is scripted and formulaic. They identify the stages in the script as (1) motivate the research through gaps in the current literature and theory by developing research questions, (2) identify a reference theory that addresses the constructs instantiated in the literature review, (3) develop a research model contextualising the reference theory with an IT artefact, (4) test the theory through well-established and

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accepted instruments, and (5) draw conclusions that support the application of the reference theory in information systems (2015, p. 281). The authors acknowledge that this standardised institutional script has improved the theoretical and empirical rigour of the discipline, but they argue that it is producing incremental and imitative mid-range theory, and that it under-theorises the IT artefact. The authors argue that the script needs to be expanded through accommodating alternative forms of knowledge production, and suggest data driven research and blue ocean theorising as alternatives. Blue ocean theorising is not synthesising existing theory through the literature review, but creating new theory through armchair speculation, thought experiments, and theoretical imagination (p. 286). They argue these alternative strategies allow for novelty and foresight, and they encourage doctoral students to use the opportunity afforded by their thesis of sustained and individual work to consider alternative scripts.

Their position is supported by Williams and Wynn (2018) in their paper offering critical realist based research as a potentially fruitful alternative to the dominant epistemic script. Williams and Wynn (2018, p. 317) describe theorising within critical realism as follows:

Theorising in CR (critical realism) is aimed at identifying the set of mechanisms that explain a given phenomenon. In order to arrive at this explanation, a researcher must begin with the knowledge of a given phenomenon, which is then used to develop a theoretical description of the existence and outcome of a given set of mechanisms which would result in the given phenomenon as described.

This thesis uses an alternative script afforded by critical realism (Williams & Wynn, 2018), and follows the critical realist methodological model for the explanation of events in open systems (Bhaskar, 1975, 1986, 1993, pp. 74–75). The methodological basis for the structure is drawn from the model of explanation presented by Wynn and Williams (2012) and explained in

detail in the chapter on Research Methodology, Section 3.1.2. The next section provides a broad outline of the thesis.

### 1.3.2 Outline of thesis

This introductory chapter is followed by a broad context chapter which provides the scope of the study. First, it identifies the phenomenon being examined, by establishing the New Zealand context, and defining what broadband means in the context of education. Secondly, a review of the academic literature identifies the different and competing frameworks of technology in education for learning, change and power. The divergence of the frameworks highlights the broadness of the topic and the multitude of frameworks, and directs the researcher towards focusing on the actions of the student in the classroom.

Thirdly, it places the research within information systems, by defining the key concepts in terms of the framework developed by Lee, Thomas and Baskerville (2015): the technology artefact, the social artefact, the information artefact, and the information systems artefact. Finally it identifies the two research questions.

Chapter 3 establishes the philosophical and theoretical foundations of this thesis. This thesis follows the philosophy of critical realism, and the first part of this chapter outlines the metatheoretical assumptions of critical realism. Section 3.1.2 details the methodological model that informs the structure of this thesis; and links the methodological model to the core commitments of critical realism.

Activity theory provides the theoretical framework, which centres and highlights the actions of the students in this research, and provides the core analytical structure and concepts. Activity theory's long consideration of the tool provides a theoretical basis with which to consider the technology artefact and the information artefact. An important development in activity theory on the conceptualisation of information was contributed by Nuthall and Alton-Lee (Alton-Lee & Nuthall, 1990; Nuthall, 2001b, 2001a, 2004,



2007). Their work on information and the construction of knowledge, which is the basis of the conceptualisation of the information artefact in this thesis, is presented in this chapter, which will also show how the information artefact is operationalised.

Chapters 4 and 5 build the infrastructure of the thesis. Education systems are open, semiotic and recursive, and the research questions are exploratory, which structure the research design. Research with students in the classroom requires special ethical consideration, which must also be central to the design. Chapter 4 outlines the research design, through the choice of case study as method, the unit of analysis and the data collection methods. Activity theory is used to enable the research to engage with the open system through multiple data collection instruments. Chapter 5 introduces the participants, before discussing the treatment of the data and the process for making sense of the data that was made possible by their participation.

Chapter 6 presents the data. The data collected was very thick, and this chapter presents the data as it was resolved into its component parts. Following with critical realist methodology described in Chapter 3, the researcher begins with knowledge of the phenomenon. The purpose of this chapter is to resolve the data into its component parts. Using deductive analysis from a priori codes from activity theory and Nuthall's typology of information, it identified the key concepts from the data.

In critical realism the resolved data is then redescribed according to theory. The application of multiple theories to the data allows the researcher to consider the data through different lenses. Chapters 7 and 8 will use two complementary interpretations from activity theory to interpret the data. First, Engeström's activity theory triangle identifies five core findings. Secondly, Leontiev's hierarchy of activity identifies cognitive, instrumental and axiological learning actions.

Chapter 9 contains the purpose of research in critical realism. Critical realism seeks to explain a phenomenon by identifying the conditions that exist for a phenomenon to occur, through retroduction. Retroduction

reinterprets the event using philosophical and social theories. A key thread from the data is that the *form* of the technology is more relevant to the students than its *materiality*. This leads to the identification of Aristotle's four causes, of form, matter, efficient and final causes, as a relevant philosophical theory. A modern interpretation of form (Roudaut, 2018) identifies a dynamic understanding where form has structuring and regulating functions.

The importance of form leads to a revindication of the understanding of tool in activity theory, drawing from German romantic philosophy (Weatherby, 2016). In this understanding the tool is a functional organ of the student, which is a singular, functionally integrated, goal-directed configuration of internal and external resources. The goal of the functional organ (student and technology) is to use the information (which is defined) to complete the learning action. Together this is the *emergent* information system.

Chapter 9 concludes by applying the reconfigured understandings of the social artefact, the technology artefact and the information artefact to the data to reveal the emergent information systems artefact, which is represented in a 2x2 matrix.

Chapter 10 concludes the thesis by discussing the findings and contributions of this thesis while acknowledging its limitations and hope for future research.

## 1.4 Conclusion

This thesis seeks to understand technology in the classroom from the experience of the student. This neither privileges the technology nor the education. Instead it focuses on how students engage with technology on a daily basis, inquiring into the technology that they choose to use, to achieve the objectives that the students have identified. This thesis approaches the research through the philosophical and theoretical frameworks of critical realism and activity theory, and through abductive and retroductive modes of inference. In its most general sense it aims to contribute towards an

understanding of technology in the classroom as an emergent unity, structured and organised by the students in their learning, and to identify opportunities and constraints within that understanding.



## Chapter 2 Background and context for the study

This thesis was motivated by the New Zealand Government's investment in ultrafast fibre optic broadband. In this chapter the background of the rollout of broadband to schools in New Zealand is presented. This will identify that grounding the research in fibre broadband is insufficient, as the scale of the fibre broadband rollout is not defined, and broadband technology needs supporting connectivity technology to be useful to the students.

With this wider understanding of technology in the classroom a review of the academic literature is undertaken. The broadness of the field and the incommensurability of the results of the literature suggest that this research moves away from the dominant epistemic script in information systems, and a data driven research approach will be adopted.

This broad remit is scoped through embedding the research in information systems, and an ontologically emergent conceptualisation of the information systems artefact is followed. This enables the exploratory research questions to be identified and key concepts to be defined.

## 2.1 The New Zealand context

This thesis was motivated by the New Zealand Government's investment in ultrafast fibre optic broadband. The ostensible policy of the Government in respect of the relationship between broadband and education is seen in the Minister's statement, "Ultra-fast broadband to schools will transform the education system" (*Hansard*, 2011). The following section will define what ultrafast fibre optic broadband meant in the New Zealand context at the time of the study (the first tranche of data was collected in 2015, the second in 2017), and how government policy framed the impact of the UFB on education.

### 2.1.1 Defining ultrafast fibre optic broadband

At the beginning of this research the materiality of the broadband, fibre optic cable, was presented as its most important property. Its function, to deliver internet services, was portrayed as less important, as this could and was being achieved by other copper or hybrid technologies but these options were dismissed. "Optical fibre technology is the most commonly preferred means of delivering Ultra-Fast Broadband services worldwide" and was the preferred material of the New Zealand Government (Crown Fibre Holdings, 2013; Ministry of Business Innovation and Employment, 2013). Fibre allows transmission over longer distances and at higher bandwidths (data speeds) than other forms of communications, with less lag. To the telecommunications provider the material was paramount, and Government investment was required to upgrade Telecom NZ Ltd's (subsequently Chorus NZ Ltd) communications backbone to fibre. What this meant for students in 2012 was that (Ministry of Business Innovation and Employment, 2012),

Over the next five years, 97.7 percent of schools and 99.9 percent of students will receive ultra-fast broadband enabling speeds of 100 megabits per second.

Five years on the Ministry of Business, Innovation and Employment stated (2017),

By the end of 2022, 87 per cent of New Zealanders in over 390 towns and cities will be able to access fibre-to-the-premises broadband with speeds close to 1,000 Megabits per second (Mbps). That's fast enough to stream ultra-high definition movies to 40 different devices simultaneously.

For the purposes of this thesis, broadband "...is taken to mean the availability of broadband services at a minimum speed of 100 Mbps Downstream (from the Internet to the user) and a minimum of 50 Mbps Upstream (from user to the Internet)" (Crown Fibre Holdings, 2013) which was the speed deemed sufficient for schools.

### 2.1.2 Not all broadband is fibre

Trying to identify the extent of the fibre rollout under the UFB and which schools are benefiting from it is, however, difficult. New Zealand's retail telecommunications markets are highly competitive, and information on the UFB is commercially sensitive. In a public document (NZCC, 2017) that contains the 2016 ISPs' share of broadband connections (p. 24) and share of UFB connections (p. 39) the information is completely redacted. Trying to draw the extent of the UFB from other documents was unsuccessful as they can be vague and contradictory.

For example, while the 2016/17 Annual review of Crown Fibre Holdings Ltd revealed that the uptake of the UFB by households that have access to it is at 40% (Economic Development Science and Innovation Committee, 2018), there is no mention of how many schools have access to fibre, and it is not clear what technology schools are actually accessing. The Minister of Communications said in January 2016 that "all schools can now connect to the information superhighway that is our Government-funded broadband network" as the major school broadband project was completed, and that

“almost 2500 schools have had fibre laid to their school gate ... 97 per cent of schools covering 99.7 per cent of students are now able to connect to Ultra-Fast Broadband” (Adams, 2016).

Determining which of the schools have fibre laid to their gate for this study was not able to be determined as the documents that are in the public domain are inconsistent. For example, Karori Normal School, a primary school in Karori, Wellington (that is not in this study), was identified in May 2017 on the Ministry of Education website as being able to connect to broadband through the Chorus UFB initiative, Figure 1. Given the wording of the above Ministerial press release, the accompanying excel spreadsheet<sup>2</sup>, Figure 2, and the websites of the Ministry of Education, the Ministry of Business, Innovation and Employment, and Crown Fibre Holdings, it seemed reasonable to assume that the school had ultrafast broadband over optic fibre. The principal of the Karori primary school also thought the school had fibre provided under the UFB (Private conversation, 2017). Yet in that same month, May 2017, the Chorus website showed that it had no fibre in Karori and deployment was scheduled for late 2019, Figure 3, contrary to the government documents which identified Chorus as the provider of the fibre connection to this school in Karori. These documents indicate that it was not possible to identify with certainty which schools had access to fibre through the UFB initiative during the study without actually asking the technology teams in the schools.

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<sup>2</sup>

<http://www.beehive.govt.nz/sites/default/files/Schools%20by%20region%20able%20to%20connect%20to%20broadband.xls>



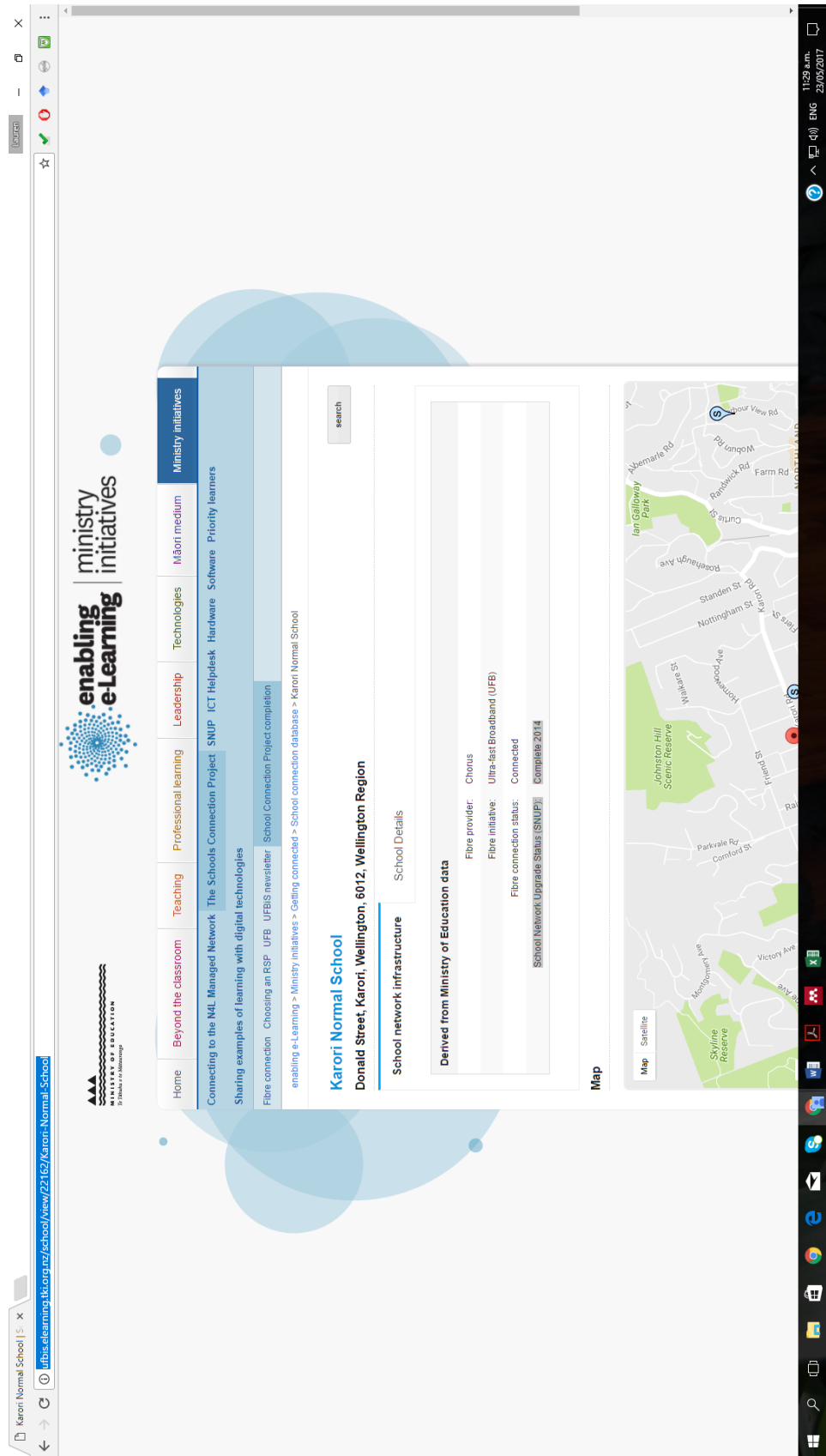


Figure 1: Screenshot of a Karori primary school's access to the UFB on the Ministry of Education's website dated 23 May 2017.


 <b>UFB and RBI Schools 2012 - 2015 Deployment Schedule</b> <b>Updated 1st September 2013</b>						
1						
2	* Data sourced from: <a href="http://www.educationcounts.govt.nz/directories/list-of-n-s-schools">http://www.educationcounts.govt.nz/directories/list-of-n-s-schools</a>					
3						
	MoE School Number *	Programme	School Name	School Address	UFB / RBI Area	Status
4	3700	UFB	Abbotsford School	72 North Taieri Road, Abbotsford	DUNEDIN / SOUTH DUNEDIN	Expected by end of Sep 2013
5	1031	RBI	Karetu School	40 Kura Road	WHANGAREI	Completed
561	3756	RBI	Karitane School	173 Coast Road	DUNEDIN / SOUTH DUNEDIN	Expected Jan - Jun 2014
562	2874	UFB	Karori Normal School	2 Donald Street	WELLINGTON / PORIRUA	Completed
563	2875	UFB	Karori West Normal School	19 Allington Road	WELLINGTON / PORIRUA	Completed
564	3394	UFB	Karoro School	0 Main South Rd, Karoro	GREYMOUTH	Expected by end of Oct 2013
565	117	RBI	Katikati College	35 Beach Road	TAURANGA	Completed
566	1765	RBI	Katikati Primary School	32 Beach Road	TAURANGA	Completed
567	1326	RBI	Kaukapakapa School	977 Kaipara Coast Highway	GLENFIELD / MAYORAL DRIVE	Completed
568	1327	UFB	Kauri Park School	0 Mcglashen Place	GLENFIELD / MAYORAL DRIVE	Completed
569	1032	RBI	Kaurihohore School	71 Apotu Road	WHANGAREI	Completed
570	1328	UFB	Kaurilands School	109 Atkinson Road	GLENFIELD / MAYORAL DRIVE	Completed
571	536	UFB	Kavanagh College	340 Rattray Street	DUNEDIN / SOUTH DUNEDIN	Existing Fibre - TBC
572	1766	UFB	Kawaha Point School	72 Aquarius Drive	ROTORUA	Completed
573	1033	RBI	Kawakawa Primary School	31 Albert Street	WHANGAREI	Completed
574	655	RBI	Kawerau Putauaki School	87 Fenton Mill Road	WHAKATANE	Expected by end of Dec 2013
575	1770	RBI	Kawerau South School	175 Onslow Street	WHAKATANE	Completed
576	2758	RBI	Kawerau Teen Parent Unit	40 Balance Street	WHAKATANE	TBC
577	1771	RBI	Kawhia School	TBC	HAMILTON	TBC

Figure 2: Extract of deployment scheduled showing status as completed in Karori on 1 September 2013.

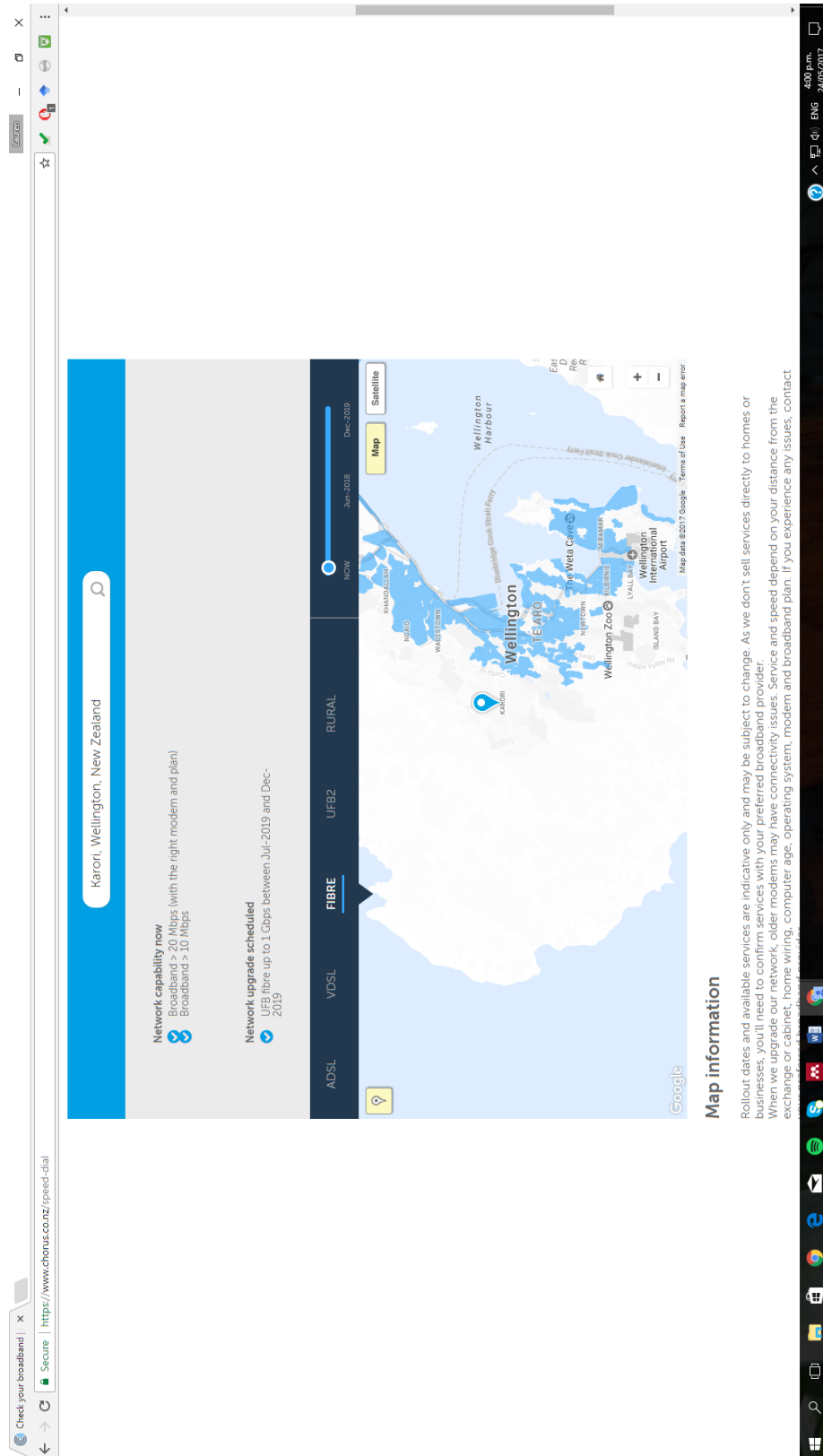


Figure 3: Screenshot from Chorus's website showing no fibre in Karori and upgrade only scheduled for 2019, dated 24 May 2017.

It cannot be determined conclusively from public documents which schools have access to fibre through the UFB initiative. What 80% of New Zealand homes and business do have access to is broadband over the copper network via vectored VDSL (Chorus, 2017), “..a technology upgrade at your local telecommunications cabinet that improves the speed and stability of a VDSL connection by reducing interference” (Chorus, 2018).

Vodafone’s FibreX, a hybrid fibre coaxial cable network, offers download speeds of up to 700-900 Mbps and upload speeds of up to 90-95 Mbps<sup>3</sup>, well above the required speeds of 100 Mbps down and 50 Mbps up defined by Crown Fibre Holdings, see Section 2.1.1. Vodafone’s spokesperson stated, “We delivered [FibreX] through a significant investment in our own HFC network. We are proud of the product and the network it runs on. FibreX has enhanced broadband competition in New Zealand and offered consumers a fibre-comparable user experience” (Pullar-Strecker, 2018). It appears that all providers are including *copper broadband* (Chorus, 2017) within their stated *ultrafast broadband* connections. This thesis does not deny that fibre offers better transmission over longer distances, at higher bandwidths, with less lag than copper networks. However, there is a range of technologies available, with some hybrid or vectored VDSL offering services which are just as effective for the consumers, and the information on exactly which technology is being offered to whom is opaque (Pullar-Strecker, 2018).

It appears that while the *materiality* of the technology was stressed as important for the initial Government investment, downstream for the consumers that information is not in the public domain. For the consumers the providers stress the *functionality* of the technology. The technology artefact in this research cannot be limited to UFB broadband, as it cannot be identified with any certainty where the UFB has been deployed.

This was the first indication in the research journey that the materiality of the technology could not be assumed, and that, despite the rhetoric and

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<sup>3</sup> 1 November 2018, <https://www.vodafone.co.nz/broadband/ultra-fast/fibrex/>

public statements, for the consumers what the technology *does* is more important than what the technology *is*.

### 2.1.3 Broadband needs to be considered in conjunction with other technology

Further reading of New Zealand policy documents show that in order to achieve the anticipated outcome of transformation of education with ultrafast broadband other technologies have to be considered in conjunction with the fibre. The Ministry of Education's Annual Report (2017) stated:

We continue to improve schools' digital infrastructure to ensure that every student in every school has access to high quality and reliable ICT infrastructure and broadband. As at 30 June 2017, 2,394 (98% of) schools have access to unlimited, fast, reliable and safe internet through the managed network (Network for Learning<sup>4</sup>). There are 798,000 students and teachers using the network on a daily basis across New Zealand.

We have also retrofitted ICT networks in 786 schools with wireless equipment. Wireless networks provide more flexible digital learning and teaching, by ensuring that schools are able to make full use of their ultrafast broadband connection, enabling students to bring their own devices, and giving teachers and students better ways to work.

This quote illustrates two points. First, in the policy documents the technology moved from ultrafast fibre optic broadband (Ministry of Education, 2011b) to fast broadband, and the requirement for optic fibre

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<sup>4</sup> The education managed Network for Learning ([www.n4l.co.nz](http://www.n4l.co.nz)) is a Crown-owned company which fundamentally performs as an educational internet service provider for schools.

was removed. In the literature broadband is rarely defined and, apart from in technical papers, the speed and the material are not stated. Broadband is essentially a commodity, and commercial requirements affect the technology that is actually being rolled out.

Secondly, the fibre optic cable cannot work alone, and the Government funding of the UFB only covers the cost of getting the fibre to the school. The Government developed complementary programmes to support the rollout of the UFB. Each school has to upgrade their wiring and switching, which is done under the School Network Upgrade Project (SNUP) and Wireless School Network Upgrade Project (WSNUP). The Ministry of Education subsidises these one-off projects, and schools pay approximately \$200 per student for State-integrated and \$150 per student for State schools (Ministry of Education, 2011a). The total for each student is approximately \$750 per student (Connect NZ, 2017). This does not include wireless access points (WAPs) and Voice over Internet Protocols (VOIP) if the schools want to use the internet for telephone services (Ministry of Education, 2016a). The schools pay for all ongoing data use, and for the desktops, laptops or tablets, software and any learning management systems that the school uses. The cost of digital technology is a major cost for schools (Tomorrow's Schools Independent Taskforce, 2018, p. 107). The student is increasingly paying for their own devices under BYOD policies. And, as stated in the Ministry of Education's Annual Report (2017), all of these are necessary parts of schools' digital infrastructure.

This section illustrates that in this thesis the wider technology that is used by the students in the classroom needs to be considered.

#### 2.1.4 Centralisation of technology and decentralisation of learning

In the Minister's statement the interaction of technology and education is conceptualised as a unidirectional relationship, from the technology to the social system, and that relationship is characterised as transformational. While acknowledging that this is a statement rather than policy, discourse

illuminates policy and the government's conceptualisation of broadband and education (Grewal, 2008).

The government convened the Education and Science Select Committee to inquire into 21st century learning environments and digital literacy that were enabled by the broadband rollout under the UFB (Education and Science Committee, 2012). The Government had already established Network for Learning Ltd, a Crown-owned company, to provide "internet services ...and managed network services enabling school-to-school connections and school-to-content and service-provider connections ... implementation, and transition" (p. 36). While the Committee recommended that the Network for Learning could provide local New Zealand content in 2012, by 2016 its sole purpose was stated as "...giving schools access to fast, reliable and safe internet is what we do, the fully funded Managed Network is how we do it" (Network for Learning, 2016).

This centralisation of the technical aspects left the "boards of trustees<sup>5</sup>, principals, and teachers free to focus on the use of the technology to deliver 21st century learning" (Education and Science Committee, 2012). Many submitters argued that because the Governmental groups the Guardians of the Secondary Futures in 2009 (which aimed to describe a 21st century learning environment) and the Ministry of Education's Digital Learning Group were disbanded with no resultant policy or legislation, there was a "lack of clear and consistent messages from the ministry on digital learning" (p 38). The Committee recommended that the Government "...provid[e] the leadership to deliver both digital capability and 21st century learning environments" (p.39).

The Ministry of Education hosted two websites during this study. The [Virtual Learning Network](#) includes a community of "[school] clusters and individuals that choose to operate as a collaborative network" and a "social

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<sup>5</sup> Boards of trustees are the governing bodies of schools, similar in function to company boards.

network for teachers, school leaders and facilitators to connect, share experiences, and learn together” (Ministry of Education, 2014). The [enabling e-Learning](#) website, which provides resources to support teachers and schools in developing their e-learning practice. These websites offer support, and examples of best practice and research for teachers, administrators and facilitators in their teaching, if they choose to use these websites. But ultimately it is up to the board of trustees, principals and teachers to determine how the technology is used in their teaching.

This section shows that while the Government developed policy and institutions to centralise the provision of the technology, the content that was to be delivered on that technology was decentralised and left to the individual schools and teachers. This suggests that there will not be standardised technology nor use of technology in the classrooms in this study.

### 2.1.5 Conclusion

In New Zealand research on technology in schools cannot be limited to fibre optic ultrafast broadband, as this technology is not able to be identified with the literature available, and it is not able to be used without other supporting technology. Thus a broad understanding of the technology artefact in New Zealand must be taken. The technology has both material cause, eg, fibre optic, and formal cause, ie, its form and its ability to do things. The next section reviews the academic literature, and identifies a range of the frameworks which can clarify how researchers view and study technology in the classroom.

## 2.2 Review of the academic literature on technology in education

Quality education is the fourth United Nations’ Sustainable Development Goal (United Nations, 2018b), as quality education is “the foundation to improving people’s lives and sustainable development” (United Nations, 2018a). This highlights two different concepts, the individual and the



society. While the UN notes that these are integrated and indivisible (United Nations, 2015) how they are balanced and their weighting depends on the political economy of the country, and of course a wide range of political economies exist that influence education policies. At one end of the spectrum can be placed Finland, which has an entirely public school system (Finnish National Agency of Education, 2017). At the other end can be placed the USA, where the mission of the Department of Education is “to promote student achievement and preparation for global competitiveness by fostering educational excellence and ensuring equal access” (US Department of Education, 2011). In this system schools need to be competitive, resulting in a mixed system of private and charter schools supplemented by public schools as a social net for those who cannot afford or are excluded from private schools (Sims, 2014).

Researchers can be found across this spectrum, and there is a wide range of perspectives brought to the literature. Researchers on the social end of the spectrum often position education as a public good where individuals benefit, where students have a sanctuary of learning and security for individual flourishing (Biesta, 2015a; Labaree, 2010; Papendieck, 2018; Sims, 2017, p. 151). On the private end of the spectrum education is often viewed through the lens of human capital theory (K. Smith, Tesar, & Myers, 2016) as a private good through which society will benefit: education produces workers with 21<sup>st</sup> century skills, who will be the basis of competitive knowledge-based economies capable of sustained economic growth (Brown, Lauder, & Ashton, 2008), and workers, through their own endeavour, will achieve social mobility (see also Goldthorpe, 2014; Young, 2001).

Education theorists have identified other purposes of education, eg, for social progress and reform (Dewey, 1897), liberation (Freire, 1970), decolonisation (Tuck & Yang, 2012), and interruption (Sumara & Davis, 1999). Other researchers have identified where education is used to disenchant, disenfranchise and disengage (Sims, 2014, 2017; Young, 1994, 2001).

How technology changes education is a question that has neither a simple nor widely accepted answer. At first glance the Minister's statement (*Hansard*, 2011), "Ultra-fast broadband to schools will transform the education system", is an addition to the long tradition of viewing new technologies as a *technical fix* that will solve underlying problems and breathe new life into backwards, broken and boring education to produce workers with 21<sup>st</sup> century skills (Biesta, 2016; Cuban, 1986; Gouseti, 2010; Peck, Cuban, & Kirkpatrick, 2002; Selwyn, 2011a, 2011b, 2012a, 2016b, 2016a; Sims, 2017). While this has been a dominant paradigm in the academic literature, in the past five years some researchers have produced more critical work (Castañeda & Selwyn, 2018).

Warschauer & Ware (2008) conducted a literature review of research on literacy and technology, and synthesized the goals, theoretical frameworks and methods of inquiry into three frameworks, which they labelled learning, change and power frameworks. In the learning framework the technology is used to improve the learning outcomes of students; the change framework changes institutionalised education by bringing it into the 21st century; and the power framework empowers youth through knowledge, access and skills.

### 2.2.1 The learning framework

Researchers in the learning framework examine how technology can enhance learning, see new technology as a step along a spectrum of development, and research how the new technology impacts learning outcomes. The framework posits that technology exerts an independent, unidirectional and causal influence over students' outputs, which is primarily measured through standardised tests. It follows a technological deterministic model, although soft versions allow for some mediation of the technology by contextual variables. While in wider information systems research it can be argued that strong notions of technology determinism have been "debunked" over several decades (Leonardi, 2013, p. 750), this

soft form of determinism is still the dominant discourse in large international, regional and national surveys of ICT in education.

For example, a study was commissioned in 2011 by the European Commission on access, use of and attitudes to ICT in schools in the EU27, Croatia, Iceland, Norway and Turkey (Wastiau et al., 2013). The purpose of the study was to benchmark national progress towards the Digital Agenda for Europe and EU2020 goals (*EU Growth strategy for the coming decade*), as education was seen to be directly linked to economic growth. This study took a broad view of the technology, and defined ICT infrastructure as including a range of devices (desktop and mobile devices including phones, tablets, laptops and notebooks), broadband (fast broadband being 10mbps or more), software (school website, email, virtual learning environment), as well as deployment in classrooms, computer labs and libraries, and the maintenance of the technology. These infrastructure features are those that were deemed necessary, but not sufficient, for use. In this study the concept of use is measured by the frequency and duration of use, the type of activity, and the digital resources used. These measures were specifically identified as the basic components of output, but not in terms of achievement or competence, which were outside the scope of the survey (p.12). As to be expected in such a broad survey there was a range of schools, with 100% of secondary students (Year 11) in Norway and Sweden being in highly equipped schools with fast broadband, while only 15% of secondary students in Romania are in highly equipped schools. Overall in Europe 55% of Year 11 students are in highly connected schools, 39% are in partially schools with less than 10mbps access to the internet, and 5% are in lowly equipped schools with no connections. The study did not find a relationship between high levels of infrastructure provision and the outputs, concluding that (p. 16), "...provision, access and connectivity do not, in themselves, lead to ICT use in learning and teaching".

The Programme for International Student Assessment (PISA) is a worldwide study by the Organisation for Economic Co-operation and Development (OECD) to evaluate educational systems by measuring 15-

year-old school pupils' scholastic performance in mathematics, science, and reading. The test is run every three years from 2000. The 2003, 2006 and 2012 tests contained questions on the role of ICT in education. The 2006 test was specifically designed to analyse the extent that investments in technology enhance educational outcomes, as "...today's labour force needs [21<sup>st</sup> century] skills and competences" (OECD, 2010, p. 14). This study found that 88% of schools were connected to the internet, although it was not defined if the connection was fast broadband, broadband or other. The study predicted a correlation between high computer use at home and high educational performance at school. It was found that students with high economic, cultural and social capital had the competences and skills to use technology, and thus achieve high scores. The policy implication drawn was that governments should raise the frequency of computer use as "only in these circumstances will clear correlations between technology use and educational performance emerge".

The 2012 report found that 72% of students used a desktop, laptop or tablet in school, and a clear correlation between technology use and educational performance emerged (OECD, 2015). The top performers in reading and maths, Korea and Shanghai-China, were not high users of computers in schools, 42% and 38% respectively. In countries where it was common for students to use the internet at school on average the performance in reading declined. Where in the 2006 test it was found that high computer use was linked to high educational performance, in the 2012 test students who spent more than six hours online reported that they felt lonely at school, arrived late or skipped school completely in the fortnight before taking the test. The report stated that (p. 15),

But where [ICT] *are* used in the classroom, their impact on student performance is mixed, at best. In fact, PISA results show no appreciable improvements in student achievement in reading, mathematics or science in the countries that had invested heavily in ICT for education.

The conclusion that was drawn by the authors was not that investment in ICT *does not* correspond to improved learning outcomes. Rather it pointed the finger at students, who lacked cultural capital, and parents, who let children spend too much time on screens, and teachers, who are not proficient in student-oriented teaching practices. The authors stated that (p. 17), “One interpretation of these findings is that it takes educators time and effort to learn how to use technology in education while staying firmly focused on student learning.”

A US meta-analysis (US Department of Education, 2010) found that while online instruction performed modestly better than face-to-face instruction, combining online and face-to-face elements had an even larger advantage. The authors caution that (p. 51) “...the findings of this meta-analysis ... should not be construed as demonstrating that online learning is superior as a medium [, nor do they] support simply putting an existing course online, but they do support redesigning instruction to incorporate additional learning opportunities online.”

A Canadian meta-analysis that found “[w]hen implemented appropriately, technology tools are beneficial to students’ learning, and may facilitate the development of higher order thinking skills” (Abrami et al., 2006), was immediately rebutted that “[s]uch findings, in part, provide a misleading conclusion that e-learning has a positive impact on achievement” (Kanuka, 2006, p. 2). A difficulty with studies compounding data can be where “positive effects of using computers to look up information and negative effects of using computers to practice skills, [result] in overall null effects” (Falck, Mang, & Woessmann, 2015).

The strength of the predominantly quantitatively researched learning framework is that the outcome of full appropriation of technology is an easily identifiable and accepted metric, and one that fits with standardised exams. The weakness is the weakness inherent in standardised exams: learning is equated solely with performance in high-stakes examination. Consequently wider skills and competencies, such as systems thinking,

information literacy, creativity, adaptability, conscientiousness, persistence, and self-regulation (Ito et al., 2013, p. 54) are not measured (Belo, Ferreira, & Telang, 2010).

Those promoting a learning framework face several challenges in demonstrating the relationship between technology and learning outcome. As indicated in the studies above, it is not the mere presence of technology that makes a difference but rather how it is used. As Belo, Ferreira and Telang (2010) state,

We do not know precisely the kind of activities students engage in with the Internet. Future work should complement this paper by either monitoring Internet connections in schools at the protocol [application] level or surveying directly teachers and students *in order to gather a deeper understanding of how broadband is effectively used* [emphasis added].

Work in this area tends to give central theoretical significance to the context within which the technology operates as a black box (in some unspecified manner the technology will improve educational outcomes), or to the discrete capacities of the technology (Orlikowski & Iacono, 2001). An individual's agency is often the determinant of causation rather than social structures or the technology, with cause being placed on students who may be distracted, or who are not effective at taking notes (Payne Carter, Greenberg, & Walker, 2017).

In conclusion two threads can be drawn from this research:

1. In this framework information technology is relatively straightforward, unchanging, discrete and deterministic. However it is a blunt tool, and as Orlikowski and Iacono suggest, research needs to move beyond a black-box view of technology to more powerful conceptualisations (Orlikowski & Iacono, 2001).

2. Research in this area is generally summative, but has not found the expected positive outcomes. Researchers suggest a future direction of research should be formative evaluation of the use of the technology by the students in the classroom.

### 2.2.2 The change framework

In the change framework technology is seen as a trigger for structural change (Kimble, n.d.). Technology is an intervention into the relationship between human agency and organizational structure, and triggers structural change by altering institutionalized roles and patterns of interaction. The change framework places new technology along the spectrum of revolutions in communication and the production of knowledge: the focus is on the technology and what new and improved outcomes it can bring to learning and literacy outcomes. Appropriation is measured by schools using and valuing the new technologies, with advocates seeking to transform pedagogy to align with current uses of the latest technology (Barbour & Wenmoth, 2013; de Hond, 2018).

The latest technology has been expected to change education for a while now:

“Books,” declared the inventor with decision, “will soon be obsolete in the public schools. Scholars will be instructed through the eye. It is possible to teach every branch of human knowledge with the motion picture. Our school system will be completely changed inside of ten years.” Thomas Edison interviewed in *The New York Dramatic Mirror* in July 1913.

A weakness of the change framework is that it assumes that the change in technology should guide a change in pedagogy, when new literacies may not actually benefit, or even engage, the intended users (Warschauer & Ware, 2008). There is an assumption that the current technology is the correct solution, and students, teachers and administrators need to change to

the particular technology that is being introduced. The technology will change the culture of the school to an innovative (Marcovitz, 2006), motivating (Boven, Harland, & Grace, 2011), or a 21<sup>st</sup> century environment (Ravenscroft, Lindstaedt, Kloos, & Hernández-Leo, 2012), and that in itself is the educational achievement. In New Zealand this change “will require a sustained investment and commitment by all stakeholders in the education sector ...[and]... could take several decades.” (Education and Science Committee, 2012)

There is an assumption in this paradigm that current schools are a problem, framing them as “traditional” schools in order to present a vision of innovative learning in a better light (Istance & Kools, 2013). “Traditional” schools are frequently described as teacher-led, using direct instruction and lectures, and generally positioned against, and less than, inquiry based and problem based learning, which use simulations, gaming, and web-based learning. Such framing ignores the research that every child experiences a classroom differently (Nuthall, 1999, 2007), that teachers contribute to learning (Alton-Lee, 2006), and that the effect on achievement is greater when the teacher is an active participant and not a facilitator for technology (Hattie, 2008; Kirschner, Sweller, & Clark, 2006). By focusing on a single technology as the solution to a problem that the authors have defined, reform is framed by the policy makers, corporate leaders and influential non-educators in terms of the technology rather than as a complex, social organisation of the school and classroom realities. Teachers are voiceless in this paradigm (Cuban, 1996).

This is the dominant discourse in longitudinal, qualitative studies (Ito et al., 2013; Laurillard et al., 2013; Orlando, 2013; Starkey, 2011). Work in this area accepts that technology is embedded in a social context, and that the outcome of learning is not to improve standardised test scores, but “...to educate students to be active participants in the society in which they live...” (Starkey, 2011, p. 37), and develop 21<sup>st</sup> century cognitive competencies that are rarely the focus of assessments of programme evaluations (Ito et al., 2013, p. 54).



In this paradigm evidence of widespread and sustainable change is lacking. Istance and Kools (2013, pp. 44–45) point to very modest evidence of positive impact on academic domains, little evidence of cost effectiveness, and little evidence of any influence to change teaching and learning strategies. They further state (2013, p. 56) that:

The very diverse ways that technology enters into shaping learning environments renders highly problematic the search for a specific ‘technology impact’ on learning — so much depends on how such technology is used and to what purpose, and in combination with everything else that goes to shape such environments.

From these studies it can be said that:

1. Successful change is rarely achievable and sustainable;
2. The structural change seen as most enabling is to the constructivist perspective, but Piaget and Vygotsky are already dominant in New Zealand teacher education (Starkey, 2011, p. 37; Timperley, Loughran, & Earl, 2008);
3. Research in this area is generally summative, examining how the technology artefact has changed the process, and hence the structure, of learning. Again, because researchers have not found expected positive outcomes it has been suggested that a future direction of research should be formative evaluation of the use of the technology by the students in their own environment, in combination with the social, political, economic and cultural contexts of education.

### 2.2.3 The power framework

The power framework focuses on the human action aspect of technology and sees technology as a product of shared interpretations or interventions:

technology is not an external object but an intentional product of human actions, design and appropriation.

The power framework focuses on the relationship of the technologies to educational and social equity, with the outcome of empowering youth through knowledge, access and skill with socially relevant tools. This framework privileges the user and the user's situation: technologies and learning outcomes are valued relative to the user. Educational achievement is valued as it is in the learning framework, however standardised testing is seen by some as a politicized and contentious issue. As with the change framework new technologies are viewed as bringing new literacies, however the power framework focuses research on the technologies that are related to social, economic and educational power. Thus appropriation of technology is the user having access to relevant technology, and identifying the social, economic, cultural and linguistic contexts in which to use this technology to achieve educationally (Warschauer, 2003).

Research in the power framework is always framed within the political economic motivations of the researcher. Much of the work is emancipatory, and references Freire and Fanon. But the power framework can also describe the research of neoliberal political scientists in the USA, who describe technology as "a magic bullet" to make American education internationally competitive by moving education online which will bust teacher unions and increase parent choice (Glassman, 2009; Moe & Chubb, 2009), and in New Zealand, where technology will motivate students to stay in school and reduce teen pregnancy (Boven et al., 2011). It is argued that research in the power framework may reduce the solution of pressing, complex, social problems to technological or educational gestures (Larabee, 2010, p. 2).

A strength of the power framework is that it can incorporate both learning and change into the user's context, to achieve the aim of enabling educational, social and economic opportunities. Some weaknesses can be identified in different research foci. In the sociotechnical perspective

outcomes can be manipulated by optimizing the fit between the social and the material, and then assuming a "better" performance will inevitably result. A social constructionist perspective can underplay the material aspects of technology (Orlikowski & Scott, 2008).

Even though this framework can be inclusive of learning and change frameworks the results from these studies are disappointing. Warschauer and Ware (2008) found that a laptop for every child programme specifically designed to help disadvantaged children still found that affluent children were better able to leverage their language and literacy skills, cultural capital, and social resources. Zillien and Hargittai (2009) found that access and use of the internet does not promote the leapfrogging of disadvantaged youth to take full advantage of the new learning opportunities that the online world has to offer. It is argued that the One Laptop One Child programme is more about the provision of technology than the provision of education (Burton, 2011; Selwyn, 2013).

From these studies it can be said that:

1. While smaller ethnographic studies of non-dominant population groups and how they interact with ICT are popular thesis topics, working with ever smaller groups means that findings may not be generalizable to other populations.
2. Power frameworks can privilege the social over the material.
3. While these studies are formative these outcomes are linked to socio-demographic factors, and show that inequalities in demographic factors are replicated in digital learning (van Dijk, 2005). A future direction of research could be formative evaluation of the use of the technology by the students.

### 2.2.4 Conclusion

Despite the amount of research on technology in education over forty years clear links between the technology and significant, sustainable positive

changes in learning outcomes or processes have not been identified. There is no general agreement on philosophy, epistemology, ontology, axiology, methodology, or unit of analysis (Boell & Cecez-Kecmanovic, 2014, p. 266), making the literature incommensurable. The lack of congruence between the various positions has resulted in irreconcilable bodies of literature. While the vast majority of research is working towards providing steps forward the extremes are still motivated by ideology and politics (Merga, 2015; Zhao, 2017). The literature review did not identify a “gap” in the literature, nor did it present a reference theory through which to structure the problem or develop hypotheses. What the literature review did provide was a direction where relevant data could be collected: the student in the classroom. This directs the research away from testing theories and hypotheses, and towards data driven research. Critical realism and activity theory are philosophical and theoretical frameworks that are grounded in data in open systems. This research is embedded in the discipline of information systems, which is discussed in the next section.

### 2.3 Defining the information system

In the social world the three most basic ontological categories are persons, symbols and artefacts (Gorski, 2016). In information systems these are equated with the categories of social, information and technology. The discipline of information systems interrogates these categories and the relationships between them. Work on defining information systems is an ongoing quest, and understandings of information systems are becoming more complex. In 2001 Lee (2001, p. iii) developed a broadly accepted (Gregor, 2006) understanding of information systems where,

...research in the information systems field examines more than just the technology system, or just the social system, or even the two side by side; in addition, it investigates the phenomena that emerge when the two interact.

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By 2015 Lee's understanding of information systems had become much more complex. Lee, Thomas and Baskerville state (2015, p. 6),

...we conceptualize 'IS artifact' so that it refers to a system, itself consisting of subsystems that are (1) a technology artifact, (2) an information artifact and (3) a social artifact, where the whole (the IS artifact) is greater than the sum of its parts (the three constituent artifacts as subsystems), where the IT artifact (if one exists at all) does not necessarily predominate in considerations of design and where the IS itself is something that people create (i.e. an 'artifact').

While this article is in design science it is relevant in wider information systems, as it responds to an ongoing quest to theorise the IT artefact (Akhlaghpour, Wu, Lapointe, & Pinsonneault, 2013; Alter, 2015; Faulkner & Runde, 2019; Orlikowski & Iacono, 2001). It places the information systems artefact as the purpose of information systems, identifying the IT artefact as important but not coterminous with the information system. It also declines to broaden conceptualisations of the IT artefact, which has led to views of technology as mangled, entangled, enmeshed and imbricated with social structure or activities, to list only a few (compare Pentland, 2013). Lee et al call for better distinctions between the IT artefact and its context, eg, environmental, social and organizational factors, and intention and use. In this understanding Lee, Thomas and Baskerville *unpack* the IT artefact from the 2001 definition into the *information artefact* and the *technology artefact*. These, with the *social artefact*, are in concordance with the three basic ontological categories. The information system comprises all the categories, and is considered its own ontological category. This *information systems artefact* is considered to be more than the sum of its parts, and is an emergent structure (Bhaskar, 1993, pp. 30, 32), see Section 9.3.1. This thesis follows Lee et al and takes a comprehensive view of information systems that individualises and contextualises the constituent

artefacts. The ontological categories and their understanding in information systems will be considered in the next sections.

### 2.3.1 The technology artefact

Lee, Thomas and Baskerville define a technology artefact as “...a human-created tool whose *raison d’être* is to be used to solve a problem, achieve a goal or serve a purpose that is human defined, human perceived or human felt” (2015, p. 8). From this definition Lee et al identified four conclusions. First, technology artefacts is a wider set of artefacts than IT artefacts. Secondly, the technology artefact is not necessarily digital, and can include a face-to-face meeting or a book. Thirdly, the technology artefact does not need to be about information, and a hammer is included within technology artefact. Fourthly, the technology artefact can be non-physical, such as a business strategy.

This thesis concurs with all of these conclusions, and draws further from Simon (1996 cited in Lee et al., 2015, p. 7), who states that:

Artificial things can be characterized in terms of functions, goals, adaptation.

This thesis agrees that the technology artefact can be characterised in terms of its functions, and will draw from the empirical data to show that both the *materiality* and the *form* of the technology are relevant to the activities of the students. It will draw from Aristotelian typology of causes in its discussion on material and formal causes, and identify that in a contemporary understanding of hylomorphism form is dynamic structure. It will draw from activity theory the importance of the purpose of the technology artefact, and the concept of the tool as a functional organ. This thesis joins with other authors in arguing for a reconsideration of form and function in information systems (Cheikh-Ammar, 2018; Goldkuhl, 2013; Markus, 2004; Markus & Silver, 2008; Pentland & Feldman, 2008).

### 2.3.2 The social artefact

The social artefact is defined (2015, p. 9) as “...an artifact that consists of, or incorporates, *relationships or interactions between or among individuals* through which an individual attempts to solve one of his or her problems, achieve one of his or her goals or serve one of his or her purposes.... they involve *the social*, not just *the individual*.” Social artefacts can include persistent social objects, and the examples given include social structures, and events, such as “...one-off ephemera in one-off interactions (such as an utterance in a conversation...)”.

This definition illustrates issues that arise with any type of categorisation. Different theorists can place similar things in different categories. While for Lee et al an utterance was a social artefact, Vygotsky specifically studied utterances as a technological tool not a social artefact; where there is a conflict this thesis will follow activity theory. Similarly, according to Lee et al a decision made in a committee meeting is a social artefact (p. 9), while a face-to-face meeting and a business strategy are technology artefacts (p. 8). Categorising things affects how they are treated in analysis. Also, different theorists include different things in the same category.

Another issue with this definition is that it excludes the individual: the artefact includes the relationships or interactions *between or among* individuals, but not the actual individuals. The authors later acknowledge that other components in the information system may be incorporated, and *people* are often identified as a component of an information system (p.18). This thesis follows both critical realism and activity theory, in which the individual in society is central to the analysis, and thus the individual *and* their relationships and interactions will be considered. This is necessary as this thesis will show that the relationship between the individual and the technology is not unidirectional; in the emergent information system the individual may use the technology, *and* the technology may modify the operations and actions of the individual.

This definition also motivates the individual's actions as attempts to *solve a problem, achieve a goal or a purpose*. Goal-directed activity is rarely included in the literature in information systems on use of technology, which focus on quantitative factors such as amount and duration of use (Burton-Jones & Straub, 2006; Sedera & Tan, 2007) or qualitative factors such as affordances and learning how to use the technology (Jasperson, Carter, & Zmud, 2005; Nan, 2011; Sun, 2007) and (in)consistencies of use (Eden & Burton-Jones, 2018). Purposeful, goal-directed activity is central in activity theory based research (Barki, Titah, & Boffo, 2007), and this thesis will also use the that framework. In this thesis the social artefact is the students in the classroom engaged in purposeful, goal-directed activity, as defined through activity theory, further discussed in Section 3.2.

### 2.3.3 The information artefact

Lee et al define the information artefact (2015, p. 8) as "...an instantiation of information, where the instantiation occurs through a human act either directly (as could happen through a person's verbal or written statement of a fact) or indirectly (as could happen through a person's running of a computer program to produce a quarterly report)." They go on to define a range of meanings of information, through identification of the *function or goal* of the instantiating information, such as to form meaning, or process data, although they note that this is not an exhaustive understanding of the information. The separation of the IT artefact into the technology artefact and the information artefact underscores that information is not coterminous with information technology.

McKinney and Yoos (2010, p. 329) described the IS predicament as that researchers use "...information as a ubiquitous label whose meaning is almost never specified". Since then there has been a significant and broad body of research on the nature of information within information systems (Boell, 2017; Boell & Cecez-Kecmanovic, 2011; Ekbia, 2009), and within critical realism in information systems (Gable, Gable, Emamjome, & Bandara, 2018; Mingers, 2014; Mingers & Willcocks, 2014, 2017). This



thesis will use the conceptualisation of information items from the work of Nuthall and Alton-Lee in education (Nuthall, 2012a, 2012b; Nuthall & Alton-Lee, 1995), which is grounded in activity theory. This is further described in Section 3.4.

### 2.3.4 The information systems artefact

The information systems artefact (2015, p. 9) is defined as much by what it is not, it is “...more than just the side-by-side concatenation of a technology artifact, an information artifact and a social artifact”, as what it is:

An IS artifact is itself a system, in which the whole (the IS artifact) is greater than the sum of its parts (the IT artifact, the social artifact and the information artifact), where the constituents are not separate, but interactive, as are any subsystems that form a larger system.

This thesis will draw from the empirical data to show that the information systems artefact is structured by the students in goal-directed learning activity drawing on the material conditions available to achieve their purpose, and is an emergent (partial) totality for the duration of unity, being the cognitive congruence of the constitutive parts, which comprises the student, the technology and the information, which are existentially constituted by their socio-cultural geo-histories. From identifying the phenomena at the empirical level, abductive reasoning will be used to identify the generative mechanism of dynamic structural form (Jaworski, 2016; Koslicki, 2008; Roudaut, 2018), which contributes to the ontological emergence of the information system (Gorski, 2016; T. Lawson, 2012).

### 2.3.5 Conclusion

This section briefly outlined a current understanding of information systems, and signalled how this thesis will develop in and contribute to the information systems discipline. The next section will draw together the issues raised in this background section, and identify the research questions.

## 2.4 Identifying the research questions

The literature review, while divergent in its findings, was coherent in the direction for future research. All of the perspectives pointed towards researching how students actually used the technology. In order to understand how technology, the student, and information work together and their emergent practices it is necessary to have a better understanding of the phenomenon.

### 2.4.1 Identifying the technology artefact

The literature identified many understandings of the technology and its purposes, which has contributed to the lack of a cohesive body of literature. The background analysis showed that New Zealand has never had an explicit policy requiring certain technology in the classroom and has embraced BYOD, so it is likely that the technology that can be found in the classroom will be different between the different schools. This chapter also revealed that considering broadband alone is insufficient, as the students will also be using wireless equipment and bringing student devices. The technology and the configuration of that technology in the classroom is unknown. Also technology in this area changes quickly. It is difficult to predict future technology as the technology could either move on completely or be merged with other technology (see Section 5.1.4).

### 2.4.2 Identifying the social artefact

Researchers in each of the paradigms suggest that a future direction could focus on the actual use of the technology by the students in the classroom (Belo et al., 2010; Istance & Kools, 2013). This indicates that research should:

1. Move into the classrooms, as that is where the students use the technology.
2. Move away from the idea of best practice and focus on the actual (Selwyn, 2012b).

3. Move away from the dominant focus on teachers and administrators (Fu, 2013) to the experience of the students (Facer, 2012).
4. Move from education in the broad political sense to education that is where "...young people learn something and not just anything, that they learn it for a particular reason, and that they learn it from someone" (Biesta, 2016, p. 34).

This thesis will follow Facer and reconceive education as "...concerned with interdependent individuals, interdependent with their unique social and technological networks and resources" (Facer, 2012). This thesis will define the social artefact as the senior secondary student in the classroom. There are five reasons to support this supposition. First, the literature review identified the potential of future research *in the classroom*, focusing on actual use by the students. Secondly, this supposition gives the study congruence with the Ministry of Education's policy to place students at the centre of the education system: "...for policy, funding and regulatory decisions to improve the performance of the system as a whole students must be the focus" (Ministry of Education, 2013). Thirdly, there is a research gap on technology in education from the student's point of view. It has been argued that the dominant academic understandings of technology and education do not privilege the voice of the learner, at best tending to speak on their behalf rather than letting them speak for themselves (Facer, 2012; Selwyn, 2011b). Fourthly, the post-compulsory schooling period is where children form interests and social identities, and establish an orientation to schooling and learning that carries through to their working lives (Ito et al., 2013). This is the age that children transition from school to work, when a suboptimal start often leads to progressive and compounding inequality (Lagana, Chevillard, & Gauthier, 2013). Senior students are often self-directed and can choose and control their learning resources. They are required to complete extended thinking tasks such as interpreting results or analysing multiple texts, which requires them to recall information and engage in strategic thinking. They are also more experienced with technology, and are already expected to be competent in common

technology tasks such as emailing, searching, and accessing their learning management systems (LMS). These are the information practices that they will carry with them into work or further education. Fifthly, senior secondary students are of an age to consent to participate in research (see further Section 4.1)

Identifying these first two artefacts, and the relationship between them leads to the first research question:

**RQ1: What is the technology artefact that the students are using in the classroom?**

### 2.4.3 Identifying the information artefact

The literature on information (Section 2.3.3) identified multiple, complex and, in most cases, incommensurable conceptualisations of information. This thesis is focusing on the technology artefact, and will not enquire further into the information artefact, which could comprise a thesis in its own right. Nor is this thesis able to identify the information artefact in education. First, it is not a thesis in education, and it does not investigate the work that the students create. Secondly, this thesis does not have the resources to corral the data from a classroom of videoed and microphoned students. There is, however, a study that has done exactly this, and developed a taxonomy of information in the classroom, and this thesis will build upon that work of Nuthall and Alton-Lee, which will be further discussed in Section 3.4.

### 2.4.4 Identifying the information systems artefact

The information systems artefact is the essence of the phenomenon being investigated. The literature review pointed to the need to identify how the technology is being used by the students in the classroom. Identifying the individual components is necessary but not sufficient. Understanding the interaction of these three artefacts that are representative of the basic

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ontological categories, and the emergent information systems artefact that arises from their interaction, is the basis of the second research question:

**RQ2: How do students engage with the technology artefact and the information artefact in the classroom?**

In using the philosophical framework of critical realism this research seeks to explain the phenomenon. Thus this question cannot be answered solely through the data and findings, it is necessary to identify the structural causes and generative mechanisms that underlie the students' use of the technology in the classroom. Critical realism is further discussed in Section 3.1.

## 2.5 Conclusion

This section outlined the background to the study. It identified that while this thesis was motivated by the UFB in the New Zealand context the technology that a student engages with in the classroom is going to be much wider. In the academic literature the definitions of technology were highly varied, although most studies pointed to the need for further investigation into the use of the technology in the classroom. This moved the thesis away from the dominant script towards a data driven study that starts by investigating the phenomenon. To place some scope on this open system the thesis was embedded in information systems, and defined by core concepts of information systems: the technology artefact, the social artefact, the information artefact and the information systems artefact. Through these definitions the exploratory research questions were developed. The next section considers the research methodologies that are able to structure the research to find the answers to these questions.



## Chapter 3 Research methodology

The literature shows that the methodology needs to be able to incorporate a view of information systems as an emergent system, comprising information, technology, and social artefacts, embedded in a complex and social context. It needs to be robust enough to collect data in an open system. These requirements have led to the selection of activity theory, which is a theoretical framework and an analytical tool.

Activity theory has been described as a high-level social theory relevant to information systems, at the same level as sociomateriality, actor network theory, general systems theory, and the work of Giddens and Weber (Alter, 2015; Linger & Hasan, 2016). There is considerable literature and special issues on activity theory in all of the information systems Senior Scholars' Basket of Journals<sup>6</sup>. Activity theory is useful for understanding change and development in work and social activity, and can account for technology in activity without privileging the social or material aspects (Karanasios & Allen, 2018). Karanasios and Allen further state (2018, p. 439) that,

...as the IS field is concerned with mediation [and] the role of technology ... we see that IS can advance and develop activity theory in new theoretical directions as

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<sup>6</sup> <https://aisnet.org/page/SeniorScholarBasket>

technologies continue to go well beyond the notion of tools as initially conceptualised in activity theory.

This thesis argues that the notion of tools as initially conceptualised in activity theory was much wider than it is usually conceptualised today, and that activity theory can develop information systems in new theoretical directions. Activity theory is grounded in the work of Lev Vygotsky (1896-1934). For Vygotsky tools were both sign and tool, and included physical and non-physical understandings, material and formal causes, and emergent powers. They were deeply integrated with nature, social systems and ourselves. These are all aspects of information systems which researchers are grappling with today. It is argued that the dominance of positivist perspectives in information systems has privileged a reductive materialism, which resulted in deflationary accounts of objects and persons, where agglomerations constitute things, and agency and mental phenomena are subsumed in the powers of physical materials. It has taken almost 100 years, but Vygotsky's understanding of tool-mediated activity has much in common with Lee et al's (2015) conceptualisation of information systems, artificial intelligence, cyborgs, embodied cognition in wearable devices, and the notion that humans may (sometimes) be an artefact in technological systems (Demetis & Lee, 2017).

This section will outline the philosophy of this thesis, which is critical realism. It will then provide a brief outline of the relevant theoretical development of activity theory, and illustrate the compatibility of critical realism with activity theory. To complete the methodological framework the information artefact, which was presupposed in Section 2.4.3, will be described.

### 3.1 Critical realism

Philosophy is implicit in all scientific work. Making philosophy explicit identifies a coherent understanding of the world and ensures a consistent



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approach to the construction of knowledge. As Collier explains (1994, p. 16),

... the alternative to philosophy is not no philosophy, but bad philosophy. The ‘unphilosophical’ person has an unconscious philosophy, which they apply in their practice - whether of science or politics or daily life.

This thesis adopts the philosophy of critical realism, and its elaboration is the purpose of this section.

### 3.1.1 Metatheoretical assumptions of critical realism

Critical realism is a philosophy of science and social science originally developed by Roy Bhaskar (1975). Critical realism is an inquiry into the nature of things and our knowledge of those things. It asks “what does (social) science as a social practice tell us what the world must be like” (Bhaskar, 1975, p. xv), and the goal of research is to explain the mechanisms that generate a certain phenomenon.

It is generally positioned as a third philosophical paradigm between Humean positivism and Kantian transcendental idealism. Critical realists can be found in sociology (Archer, 1995; Gorski, 2013; Rutzou, 2017), law (Norrie, 2010), economics (T. Lawson, 2012), politics (Woodhams, 2015), education (Núñez, 2014), and increasingly in information systems (Bygstad, Munkvold, & Volkoff, 2016; Ononiwu, Brown, & Carlsson, 2018; Radulescu & Vessey, 2009; M. L. Smith, 2006; Williams & Wynn, 2018; Zachariadis, Scott, & Barrett, 2013). This diversity has the correlate of multiple positions and interpretations, but cohering all the positions is a commitment to the development of a post-positivist philosophy. This section will describe the three core commitments in critical realism: ontological realism, epistemic relativism, and judgemental rationality, and then discuss the modes of reasoning which follows from the core commitments.

### 3.1.1.1 *Ontological realism*

A realist perspective on ontology is at the centre of critical realism. Ontological realism states that much of reality exists and operates independently of our awareness or knowledge of it, and the real world cannot wholly be known through empirical survey or hermeneutical examination. Reality comprises the *intransitive objects of knowledge*, which are those objects which we study and which exist independently of their identification, eg, gravity, the moon, sound, family. They are the real things, structures, mechanisms, processes, and possibilities of the world. These exist in the domain of the real.

Events happen because of the generative mechanisms of the real things in the domain of the real. Generative mechanisms are nothing other than “the ways of acting of things”, and are enduring and continually active (Bhaskar, 1975, p. 3). In the real world multiple things act upon multiple other things, so even if these tendencies are exercised they may not manifest in a particular outcome, nor in a constant conjunction of events. The effects of these tendencies are events, which occur in the domain of the actual. These may be observed as our experiences which can be captured as empirical data, which occur in the domain of the empirical. These domains are represented in Table 1 and as a Venn diagram in Figure 4

	Domain of the real	Domain of the actual	Domain of the empirical
Mechanisms	✓		
Events	✓	✓	
Experiences	✓	✓	✓

*Table 1: Ontological realism and the existence of mechanisms, events and experiences in the domains of the real, actual and empirical.*

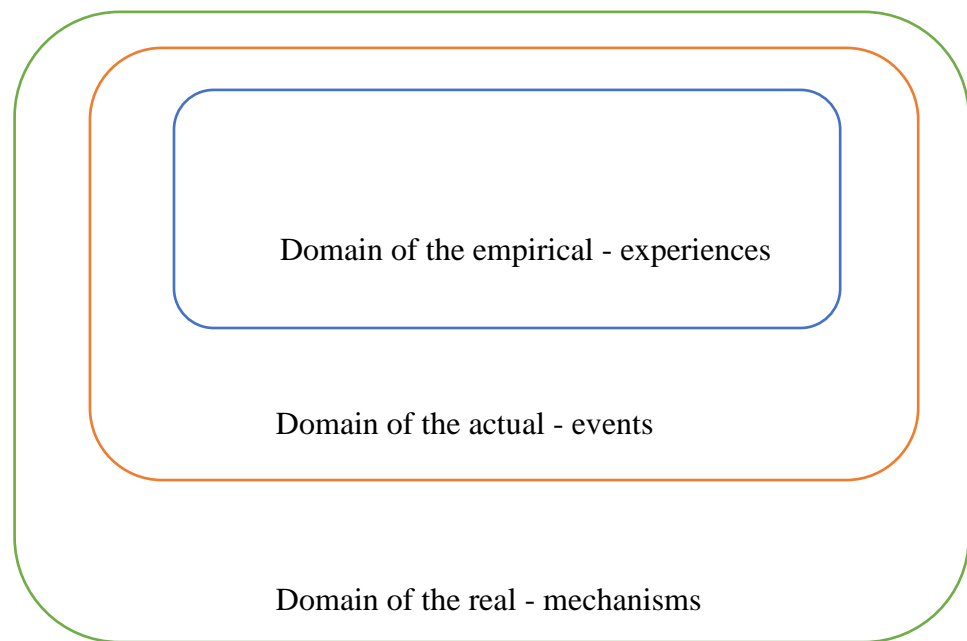


Figure 4: A Venn diagram of the critical realist domains of the real, actual and empirical.

From the empirical data that is observed the generative mechanisms are reconstructed through abductive and retroductive inferences, which are forms of logic that move from a social phenomenon to a theory which is able to account for that phenomenon. Critical realists are concerned with the abstract and philosophical questions that arise from, and undergird, the empirical investigations, and which are the basis of our theories of the world.

### 3.1.1.2 Epistemic relativism

In critical realism theories, paradigms, models, methods, and techniques are *transitive objects of knowledge* (Bhaskar, 1975, p. 12). These are wider than academic objects of knowledge. This knowledge is always relative: it is historically, socially, and culturally situated, and it is transformed by human activity. Knowledge is transient: no truth-values or criteria of rationality can be said to exist outside of historical time (Bhaskar, 1998, p. 83), which implies that our knowledge is fallible.

### 3.1.1.3 *Judgmental rationality*

Given that we cannot know all of reality (ontological realism), and that our knowledge is contingent and fallible (epistemic relativity), the criteria for judging whether accounts of the world are better or worse, and the goal of any investigation, is a descriptive or explanatory account which provides a plausible model. Bhaskar illustrated that science could be seen as a human achievement "... prone to error and open to partisan argument, and therefore to deflection from the pursuit of truth, yet at the same time grounded in real-world events and structures" (Norrie, 2010, pp. 8–9). In critical realism our understanding of the world is based on judgmental rationality between competing theories.

### 3.1.2 Methodological implications of critical realism

What do these core commitments mean for conducting research in critical realism? The crux of critical realism for research in information systems is that social phenomena exist. Social phenomenon can include objects, actions, texts, institutions, and social structures, and they exist regardless of our interpretation of them, or even our knowledge of them.

Critical realist research begins with the phenomenon: "In order to arrive at this explanation, a researcher must begin with the knowledge of a given phenomenon, which is then used to develop a theoretical description of the existence and outcome of a given set of mechanisms which would result in the given phenomenon as described" (Williams & Wynn, 2018, p. 317). The given set of mechanisms include the structures, power, mechanisms and tendencies that facilitate or produce the phenomenon.

A methodological model of explanation was developed by Bhaskar (1975, 1986, 1993) called the RRRE model; this is a general schema and not a prescriptive template (Danermark, Ekstrom, Jakobsen, & Karlsson, 2002, p. 109). RRRE stands for *Resolution*, *Redescription*, *Retroduction* and *Elimination*. This model is further discussed by Wynn and Williams (2012)

in their paper *Principles for conducting critical realist case study research in information systems*, and they illustrate it in Figure 5.

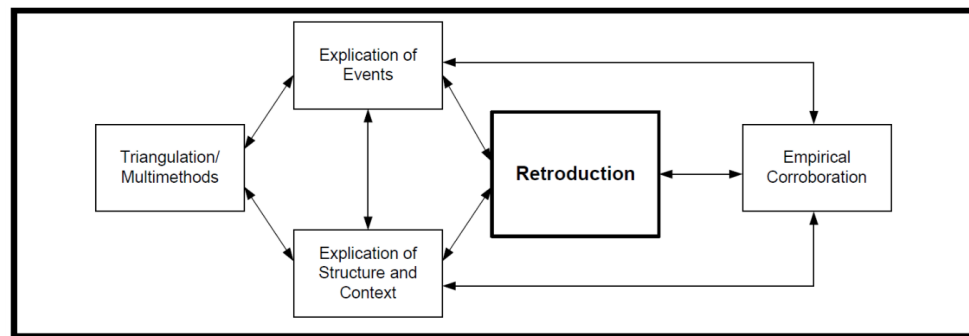


Figure 5: Relationship among the methodological principles from Wynn and Williams (2012, p. 797)

In this section the five boxes in Figure 5 are explained in terms of the four actions of the RRRE model, noting that as with any research design these are not cleanly discrete processes, and a certain amount of reiteration takes place. The first box contains “triangulation / multimethods”. This is described as “employ multiple approaches to support causal analysis based on a variety of data types and sources, analytical methods, investigators, and theories” (Wynn & Williams, 2012, p. 796). In critical realism the process of research begins with the empirical data (Fletcher, 2017, p. 185), and Wynn and Williams advocate collection of a broad range of data. There is not a corresponding term in the RRRE model.

The second box is “explication of events”, which requires the researcher to “identify and abstract the events being studied, usually from experiences, as a foundation for understanding what really happened in the underlying phenomena” (Wynn & Williams, 2012, p. 796). This is equivalent to the term *Resolution* from the RRRE model (Bhaskar, 2005, p. 142), which seeks to *Resolve* a complex event into its component parts. Critical realism is not deterministic on the methods used to resolve the data, and methods used have included deductive coding and data analysis (Fletcher, 2017), econometric modelling and qualitative analysis of interviews (Zachariadis et al., 2013), and critical grounded theory (Belfrage & Hauf, 2017). The Resolution of the data is presented in Chapter 6, Presentation of the data.

The third box is “Explication of structure and context”, which in terms of the RRRE is to *Redescribe* the components which have been resolved from the data into theoretically significant terms, which in this thesis is with activity theory. In critical realism the complex, open-systems have multiple structural entities and contextual factors, and multiple relationships among them. Our understanding of the relationships is from our epistemological knowledge of them, thus in critical realism, at this stage, theory is brought in to explain how the components are structured, and the context of the phenomenon. This redescription uses theory to understand the interaction of the components of the phenomenon. This is also known as abduction, which is further described in Section 3.1.3. Redescription of the data is presented in Chapters 7, Activity theory analysis, and 8, Hierarchy of activity analysis.

The fourth box is “Retroduction”, which seeks to identify possible generative mechanisms that caused the event. Our understanding of the generative mechanisms is drawn from theory of the world, and often critical realists draw from philosophy and social sciences to understand the world, and thus the event (Bhaskar, 2005, p. 142). Both *redescription* and *retroduction* highlight the key role played by theory in understanding the phenomenon. It is also significant that retroduction does not necessarily refer to the data, but may be linked to only boxes 2 and 3, where the data has already been *resolved* into its component parts, and *redescribed* into its relationships and contexts. Retroduction is further described in Section 3.1.3. Retroduction is presented in Chapter 9, Identifying the generative mechanisms.

The last box is the “Empirical corroboration” or *Elimination* of alternative possible causes of explanation. In an open system critical realism accepts that at all stages of explanation there are a multiplicity of causes and a plurality of effects, and key to explanation is using theory to understand the data. Here the plurality of possible causes in open systems is considered, until a concrete applied explanation can be said to have been provided. This

may be followed by a regressive movement in which the initial phenomenon is redescribed in terms of its causes (Bhaskar, 1993).

The core commitments and methodological model mean that research in a critical realist paradigm is profoundly different from research in an empiricist paradigm, which can be illustrated with the issue of validity (Zachariadis et al., 2013, pp. 858–859). While an empiricist is concerned whether observed variables are causally linked (internal validity) the critical realist is concerned whether the mechanism hypothesized is involved in the observed event. An empiricist seeks to find if the cause-effect relationship can be generalised, whereas the critical realist is concerned whether the mechanism also caused similar, or different, outcomes.

The next section describes abduction and retrodution in more detail, as they are not common modes of inference, and the role of theory in explanation in critical realism.

### 3.1.3 Modes of inference

The critical realism process of creating transitive objects of knowledge (our theories, models and methods) differs from empiricist and interpretivist conceptions (Danermark et al., 2002, p. 90). Following from the stratified understanding of reality, the crucial task for critical realist researchers is to move beyond identifying phenomena at the empirical level, ie, that which is observed, to the domain of the real, ie, the generative mechanisms and transfactual conditions. It is because of these fundamental and constituent properties and structures that exist in reality that the event can occur and be observed.

In critical realism this is done through abduction and retrodution. These modes of reasoning are becoming more prevalent in information systems research, even in paradigms other than critical realism (Hafermalz, 2016; Iannacci, 2018; Mueller & Urbach, 2017; Ochara, 2013). While there are multiple definitions of these modes of inference (Radulescu & Vessey, 2008, 2009) this thesis follows Danermark et al (2002, pp. 93–95). This

section differentiates critical realist modes of inference from deductive and inductive modes of reasoning, before discussing abduction and retrodution more fully.

Deductive reasoning is central to the dominant epistemic script in information systems (see Grover & Lyytinen, 2015 and Section 1.3.1), where the researcher “proceeds from a general rule and asserts that this rule explains a single case” (Alvesson & Sköldbberg, 2018, p. 4). In this practice the researcher builds a research model founded on reference theories, and uses given premises and universal laws to establish hypotheses. The theory is tested by collecting and analysing the data, through which logically valid conclusions can be drawn with deductive reasoning. The issue for the critical realist is that in an open system there are a multiplicity of causes and a plurality of effects, and it may be that the exercise of a mechanism may not manifest in a constant conjunction of events, or even in a particular outcome.

Inductive reasoning is used in data driven research (Grover & Lyytinen, 2015). Data is collected on the phenomenon, patterns in the data are identified, and logically valid conclusions are drawn from the data to devise new constructs and theories, which can be generalised to the entire population. From a critical realist point of view this limits understanding to the level of the domain of the empirical, and places causes at the level of the empirical.

Both deductive and inductive reasoning are subject to *epistemic fallacy*. Statements of the knowledge of being in the domain of the experienced is transposed into statements of being, ie, in the domain of the real, thus ontology of the world is conflated with the epistemology. In critical realism our knowledge of the world is not coterminous with the world. Abduction and retrodution are used in critical realism because of the core commitment to ontological realism, that the phenomenon which is experienced in the domain of the empirical is an instantiation of the generative mechanisms being exercised in the domain of the real.



The different modes of inference are reported in Table 2, which provides a brief outline of each type of mode of inference with their strengths and weaknesses taken from Danermark, Ekstrom, Jakobsen and Karlsson (2002). Abductive and retroductive reasoning, as the modes of reasoning used in this thesis, are discussed in more depth in Section 3.1.3.1.

	<b>Deduction</b>	<b>Induction</b>	<b>Abduction</b>	<b>Retroduction</b>
Fundamental structure/thought operations	Given premises or universal laws to deduct through logic valid conclusions and knowledge of phenomena.	From observations logically induct valid conclusions which can be generalised to a whole population.	To interpret and redescribe observed phenomena within a conceptual framework.	From an abductive redescription reconstruct the basic conditions for the phenomena to occur.
Formal logic	Yes	Yes	Yes and no	No
The central issue	What are the logical conclusions of the premises?	What are the common elements of the sample that can be generalised to the population?	What meaning is given to something interpreted within a particular conceptual framework?	What qualities must exist for something to be possible?

	<b>Deduction</b>	<b>Induction</b>	<b>Abduction</b>	<b>Retroduction</b>
Strength	Provides rules and guidance for logical derivations and investigations of the logical validity in all argument.	Provides guidance in connection with empirical generalizations, and possibilities to calculate, in part, the precision of such generalizations.	Provides guidance for the interpretative processes by which we ascribe meaning to events in relation to a larger context.	Provides knowledge of transfactual conditions, structures and mechanisms that cannot be directly observed in the domain of the empirical.
Limitations	Deduction is strictly analytical on the defined premises, and does not say anything new about reality.	Induction draws from and its conclusions are restricted to the empirical level.	There are no fixed criteria from which it is possible to definitively assess the validity of an abductive conclusion.	There are no fixed criteria from which it is possible to definitively assess the validity of a retroductive conclusion.
Rigour / probability of truth	--	--	--	Confirmation through contrast; stages of reflection; economy / parsimony

Table 2: Key aspects of modes of inference from Danermark, Ekstrom, Jakobsen and Karlsson (2002).

### 3.1.3.1 *Abduction and retroduction*

Critical realist mechanism-based explanation is in distinction to deductive and inductive explanation, which examine experienced events in the domain of the empirical. Bhaskar cites Marx who says ‘... all science would be superfluous if the outward appearances and essences of things directly coincided’ (Marx, 1966, *Capital* in Bhaskar, 2005, p. 8). Critical realism seeks the essence of things, and proper explanations should detail “... the cogs and wheels of the causal process” through which the event was brought about (Hedström & Ylikoski, 2010, p. 50), which are the mechanisms in the domain of the real.

Abduction and retroduction are used in critical realism because of the presupposition of the stratified ontology. The world is an open system, which consists of enduring and acting things, which endure and act in their normal way, unless they are acted upon. In an open system multiple things act upon multiple other things; there is no reason for the past to resemble the future. What we experience or observe in the world may not be *all* of the relevant events, may not be the *entire* relevant event, and the empirical data is not considered proof of a stable and objective reality. What is observed does not exhaust all the possibilities of the ontological categories. A constant conjunction of events is not in itself sufficient or necessary to generalise to causal laws. In critical realist terms the domain of the real includes all events whether or not they have been actualised (in the domain of the actual) or experienced (in the domain of the empirical). Knowledge of social reality can only be obtained by going beyond what is observed to develop concepts about the transfactual conditions of the event. Knowledge of the events, and knowledge of the knowledge of the event (ie, our theories and hypotheses of the event) are contingent and fallible. Thus our knowledge of the event that we experience is not derived from formal logic or logical inference. It is derived from being able to interpret the event in different frameworks or theories through abduction. The value of abductive analysis is that it challenges and invites reflection on both the literature and assumptions, to give new meaning to already known phenomena. The

frames can be used to complement each other, or may be able to be integrated. Researchers may find a novel insight and identify new connections.

*Retroduction* seeks to identify the generative mechanisms underlying the event. Critical realism presents a (Bhaskar, 2005, p. 178),

... non-anthropomorphic generative analyses [that] can immediately explain why it is that we pick out the particular factor that, in the pragmatic context of our concerns, we do: namely, because it is the factor which, in the real context of the genesis of the event, made the difference, tipped the balance, produced the outcome. Paradigmatically, such a factor is an agent or structure, but it may also be a condition (present or absent), state or event.

A generative mechanism is “nothing other than the ways of acting of things. And causal laws must be analysed as their tendencies. Tendencies may be regarded as powers or liabilities of a thing which may be exercised without being manifest in any particular outcome” (Bhaskar, 1975, p. 3).

In an open system there is frequently more than one generative mechanism at work, because there are many “things” in an open system. The things either *are* a causal power, eg gravity, or *possess* a causal power, and this thesis will argue that the technology artefact possesses causal powers.

Once the event has been interpreted and contextualised then the next step is to ask what are the basic conditions for this event to occur. The questions are of the forms *What properties must exist for X to exist and to be what X is?* and *What characteristics make X what X is?* (Danermark et al., 2002, p. 130) and *What must be the case for this event to be possible?* (Bhaskar, 1975, p. 29). The questions can be answered by referring to philosophical and social theories. Philosophical theories can illuminate intentionality and the conditions of human activity. Social theories can reconstruct social

structures such as power, social positions and social conventions. Theories help to conceptualize objects and structures at the abstract level about necessary or internal relations while they remain agnostic about relations which are contingent (Zachariadis et al., 2013, p. 863).

Abduction and retroduction are not discrete processes. The abductive redescription into different frameworks requires reference to the philosophical and social theories of those frameworks, and retroductive consideration requires application of the philosophical and social theories to the redescribed empirical data.

### *3.1.3.2 Role of theory in critical realist research*

Theory in critical realism has a different role from theory in other research paradigms. In Humean empiricism theories present hypotheses of relations between observable events, and the validity of the theory is assessed against the data; theories are highly general, express regular relationships that are found to exist in the world, and contribute predictive and explanatory knowledge of the world. In Kantian idealism theories are constructions of imagined relations between phenomena, which cannot be true or false, but can be more or less useful.

In critical realism research theory and data are intrinsically related because while *intransitive* reality is independent of our *transitive* knowledge of theory and concepts, we cannot understand reality without using our knowledge. Our knowledge of reality is contingent, but is not simple or arbitrary. Our knowledge is fallible, but not equally fallible. Our theories and concepts are constantly being developed, and they are developed in relation to the experiences we obtain when we use them to understand reality. In critical realism theories are descriptions of the structures and mechanisms which causally generate the observed phenomenon.

In critical realist research there is not a linear progression from theory to data. Both theory and data are intrinsic to the abduction and retroduction modes of inference, as identification of structures and mechanisms through

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retroduction can only be achieved by the means of abstract concepts and theories.

The term “theory” derives from the Greek root *theoria* that privileges seeing, and thus one function of theory is to help individuals see and interpret phenomena and events. Theories are thus ways of seeing that provide understanding and modes of interpretation which focus attention on specific phenomena, linkages, or the social system as a whole... theories are seen as tools that help us see, operate, and get around specific social fields, pointing to salient phenomena, making connections, interpreting and criticizing, and perhaps explaining and predicting specific states of affairs.... Social theories provide maps of societal fields that orient individuals to perceive how their societies are constructed.... Social theories are thus heuristic devices to interpret and make sense of social life (Kellner, 1995, pp. 24–25).

This quotation sums up how theories are useful as frameworks of interpretation, especially in the abduction and retroduction phase of the research, where they may aid in the identification of the structures and generative mechanisms.

#### 3.1.4 Conclusion

The literature review identified that data driven research is appropriate for understanding this phenomenon (Section 2.2.4), and critical realism has methodological processes appropriate for working from data (Williams & Wynn, 2018). The first step of critical realist research is to gain knowledge of the *content* and *structure* of the phenomenon, and then through abduction and retroduction to develop a theoretical description of the existence of the generative mechanisms. An appropriate theory for understanding the *content* and *structure* of the phenomenon is activity theory, which will be discussed in the next section.

### 3.2 Activity theory

Activity theory is a psychological paradigm, framework, or meta-theory initially developed in the former Soviet Union in the first half of the twentieth century. The key theorist is Vygotsky, and activity theory is based on his psychological research identifying that purposeful human activity, mediated by tools and signs, plays a vital role in the development of the psyche, and individual development is therefore rooted in society and culture. Other key theorists widely recognised are Leontiev and Luria, and there are many students and researchers who have contributed to the theory (Mironenko, 2013; Yasnitsky, 2016). Activity theory has continued to develop, diversify, and thrive around the world. For example, in the Russian Federation work has developed in system structural activity theory (Bedny & Karwowski, 2003), in Scandinavia as cultural-historical activity theory (Engeström, 2015), in the United States with human-computer interaction (Nardi, 1996) and the mediational theory of mind (Scribner & Cole, 1973), in Brazil with cultural historical psychology (Rey, 2016); as well as through influencing other theorists (eg, Kurt Lewin and action research, Yasnitsky, 2012). The importance of the social and historical context to activity theory leads to the umbrella term of cultural historical activity theory, or CHAT, although this thesis will refer to it as *activity theory*.

Activity theory posits that mental processes first occur *interpersonally* between people, such as the baby and parent, or the child and a knowledgeable other, and over time it will be internalised by the child as an *intrapersonal* process (Vygotsky, 1978, p. 57). Development and learning are social and cultural experiences, and tools and signs mediate that experience. Thus even though learning cannot be observed directly, Vygotsky directs us to observe and understand the tools and signs, and the behaviour and the activity of the child.

This thesis is investigating how digital tools (the technology artefact) mediate learning, and it will establish that tools as understood in Vygotsky's time as natural, functional and organic give a better account of



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digital tools and how they are used in the classroom then the discrete, material, reductionist conceptualisation that is common today. To do that an overview of the development of activity theory is necessary, however a detailed investigation into the origins and development of activity theory is outside the scope of this thesis. The purpose of this section is to identify the key ideas that are relevant to this thesis. This thesis takes the position that Marx and Engel's influence on Vygotsky was strong (Ratner & Silva, 2017, pp. 2, 4). This section will next discuss activity in Marx's philosophy and its relevance to the tool.

### 3.2.1 Activity in Marx's philosophy

A central tenet of Marx's philosophy is that *activity* is the basis of human life. This statement is worth considering in some depth because Marx's philosophical work is the basis of activity theory and critical realism. Marx wrote (1845) (text in italics added),

In direct contrast to German philosophy [*ie, Kantian idealism*] which descends from heaven to earth, here we ascend from earth to heaven [*as in romantic philosophy*]. That is to say, we do not set out from what [humans] say, imagine, conceive, nor from [humans] as narrated, thought of, imagined, conceived, in order to arrive at [humans] in the flesh. We set out from real, active [humans], and on the basis of their real life-process we demonstrate the development of the ideological reflexes and echoes of this life-process. The phantoms formed in the human brain are also, necessarily, sublimates of their material life-process, which is empirically verifiable and bound to material premises [*ie, Marxist materialism*]. ... Life is not determined by consciousness, but consciousness by life.

Less poetically and more directly Engels wrote in the *Dialectics of nature* (1883),

It is precisely *the alteration of nature by [humans]*, not nature as such, which is the most essential and immediate basis of human thought.

Activity according to Marx is material, epistemological, and philosophical (Livergood, 1967). Before Marx materialism used to be conceived of as a mechanistic explanation of motion and change. For Marx activity is the form and essence of material, existential human life, an internal propelling force, an immanent principle which explains and entails progressive development; this is the principle of dialectical activity. Activity is central to epistemology: humans actively create knowledge (epistemic relativism), and as we can experience the empirical world then there is an independently existing world (ontological realism). The truth of our knowledge is tested by practice (judgmental rationalism). Philosophically, our knowledge is not a passive reflection of reality, but an active instrument of change to assist in the transformation of society. Critical realism also conceives of social science as an explanatory, and thence emancipatory, critique (Bhaskar, 1986).

Human life and human development is in unity with biological development (phylogenesis or evolution), cultural and historical development, and individual development (ontogenesis) (Blunden, 2015). Activity is the essential mediating link between the individual and the environment, and is deeply rooted in the cultural, historical and social environment.

### 3.2.2 Vygotsky

There is a direct line from Marx's formulation of the world, humans and activity to Vygotsky's work in psychology. The fundamental premise underpinning all strains of activity theory is that purposeful human activity, mediated by socially developed tools and signs, precedes and is the basis of

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the development of nature and ourselves. Vygotsky's work on child development, the zone of proximal development (Chaiklin, 2003), the role of the knowledgeable other in teaching/learning /*obuchenie* (Daniels, 2012), lived experience / *perezhivaniye* (Blunden, 2018; Flear, Rey, & Veresov, 2017), double stimulation (Sannino, 2015a), generative learning (Wittrock, 2010), and more, has informed this thesis, but the most relevant monograph is *Tool and symbol in child development*<sup>7</sup>. This thesis uses the English translation in *Mind in society* (1978).

For Vygotsky activity is the internal propelling force for both development and learning. Individuals are not passive, waiting for the parent, teacher or environment to instigate meaning-making processes for them. Through purposeful activity in the world individuals make sense of the world (Hasan, 2010).

### 3.2.2.1 Tools and signs

The frontispiece of *Mind in society* (1978) features Vygotsky's portrait and a handwritten note which contains the theme of that book, which is translated as,

The essence of the instrumental method resides in the functionally different use of two stimuli, which differentially determine behaviour; from this results the mastery of one's own psychological operations.

The two stimuli are tools and signs. At its simplest the tool is physical: it is an invention to expand our ability to manipulate and shape our physical world. Tools are *externally* oriented, they conduct human influence *onto* the object of activity, and lead to changes in the world. Engels wrote (1883), "The specialisation of the hand - this implies the tool, and the tool implies specific human activity, the transforming reaction of man on nature,

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<sup>7</sup> Authorship is variously attributed to Vygotsky, and Vygotsky and Luria (Kellogg, 2011, p. 86).

production”, which was echoed by Vygotsky (p. 291) as “... humans change nature, making it serve human needs”. The tool *is used* for a purpose.

In return, the tool is shaped by its use. Engels wrote (1883),

Thus the hand is not only the organ of labour, it is also the product of labour. Only by labour, by adaptation to ever new operations, through the inheritance of muscles, ligaments, and, over longer periods of time, bones that had undergone special development and the ever-renewed employment of this inherited finesse in new, more and more complicated operations, have given the human hand the high degree of perfection required to conjure into being the pictures of a Raphael, the statues of a Thorwaldsen, the music of a Paganini.

Analysis of fossils of human bones suggest that indeed the hand did evolve as an adaptation of tool making and tool use (Marzke & Martzke, 2000).

Thus the tool *embodies* a purpose.

Sign systems are language, writing and number systems. These are necessarily created by societies, and, like tools, are spatial and temporal instantiations. Signs are internally oriented, and the activity of using signs *internalises* socially rooted and historically developed activities (Vygotsky, 1978, p. 57).

### 3.2.2.2 *Some cautions*

There are some essential differences between tools and signs; as Vygotsky stated (1978, p. 53), “Here we want to be as precise as possible”.

Vygotsky’s work was in psychology. This thesis is in information systems in the context of education, and is investigating the role of a physical tool in learning and concept development, which in activity theory are considered psychological activities. Vygotsky said that the physical tool *may* play an *auxiliary* role in psychological activity. The literature review showed that

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IT in education is generally conceived of *figuratively*, with labels such as technology enhanced learning, e-enabled capability, and statements such as broadband transforms education. States of learning, capability and education are rarely defined, and processes of enhancing, enabling and transforming are rarely elaborated. Vygotsky describes such expressions as “...usually bereft of any definite content and hardly mean more than what they really are: simple metaphors and more colourful ways of expressing the fact that certain objects or operations play an auxiliary role in psychological activity”.

The task of the researcher is to uncover the real relationship between behaviour and tools and signs. Is *learning* analogous to *using* a laptop? Does the laptop (the *means of activity*) simply support the psychological process that leans on them? What is the nature of this support? What does it mean to be a *means* of thought or of memory?

Signs and tools cannot be equated or conflated: this loses the essence of each form of activity and ignores the differences in their historic role and nature, and results in a form of determinism (Vygotsky, 1978, p. 53). Vygotsky goes on to warn that without distinctions between tools and signs they become dissolved in the general concept of artefacts.

Note that Lee et al (2015, p. 8) suggest that this has in fact happened in information systems literature, as they unpack the *IT artefact* to the *information artefact* and the *technology artefact* (Section 2.3), effectively into sign and tool. But for Lee this is not because of the conflation of two different ontological concepts, but because the technology needs to be extended into its surrounding context. For Lee the technology is neutral, and the context is socio-technical or cultural, or related to people, policies and practices. For Vygotsky, and for Bhaskar (1993, p. 33), tools are existentially constituted by their cultural geo-histories, and the use of the tool is the processuality of space, time and causality; it is a spatio-temporal instantiation of its geo-history.

### 3.2.2.3 Tools and signs and mediated activity

Tools and signs are different, but they share a characteristic which is their mediating function. Vygotsky presents their relationship as Figure 6 (1978, p. 54).

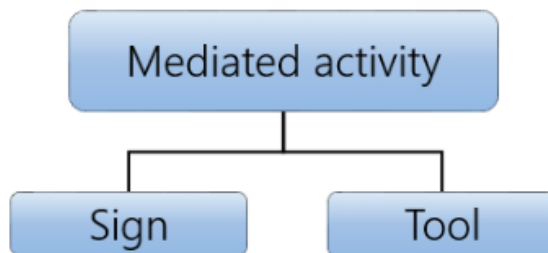


Figure 6: Sign and tool subsumed under mediated activity (Vygotsky, 1978, p. 54).

For Vygotsky (1978, p. 24),

... the dialectical unity of these systems in the human adult is the very essence of complex human behaviour. Our analysis accords symbolic activity a specific organizing function that penetrates the process of tool use and produces fundamentally new forms of behaviour.

Elementary functions are directly determined by stimulation in the environment, expressed in the formula  $S \rightarrow R$ , where S is the environmental stimulus and R is the human response. At the most basic level an example is that when people hear a noise they turn to the source. For higher functions, such as memory and writing there is a double stimulation, and that becomes the immediate cause of behaviour. The first stimulus has the function of the task toward which the person is directed; the second stimulus uses the function of the tool or the sign to organise the activity (Sannino, 2015b, p. 1). The new, complex, mediated act is represented by Figure 7, where X is the double stimulus of the sign or the tool.

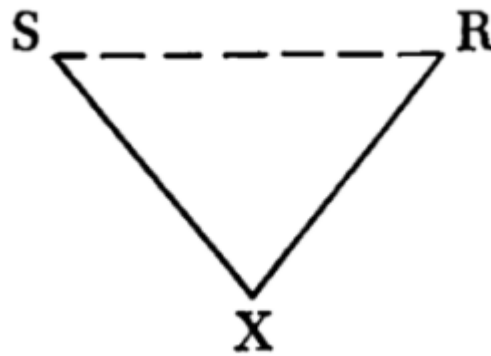


Figure 7: The mediated act, and the method of double stimulation, Vygotsky, 1978, p. 40.

The insertion of the sign or tool does not simply improve the existing operation, nor does it merely extend the Stimulus-Response chain. The sign or tool permits humans to control their behaviour from the outside, through communication, through planning, and through learning. It allows humans to break away from biological development, and creates new forms of culturally based behaviour and psychological processes (Vygotsky, 1978, p. 40).

This understanding of activity does not eliminate direct, unmediated, phylogenetic connections between the subject and the object. The argument is that for development of the baby to the child, and of the child to the adult, there is purposeful, structured, mediated activity. Figure 7 shows the minimal structures of human cognitive function (Cole & Engeström, 1993, p. 7). Vygotsky's work focused on semiotics and the sociocultural determination of the mind; it was up to the next generation to focus on the role of social, practical, object-oriented activity.

### 3.2.3 Leontiev

Leontiev asked how do we know (psychologically) the real (physical) world? The answer is that our knowledge of the world is the result of our connection and interaction *with* the world, "... of a living, highly organised, material subject and the material reality around [them]" (1959). Our knowledge of the world, "...cannot help ... [depend] on activity, cannot

help being subordinated to the subject's life relations realised by activity, cannot help being partial, since these relations themselves are partial”.

Leontiev also says that, “... [t]he organs of psychic reflection themselves are at the same time organs of this interaction, organs of vital activity”.

The passages illustrate some perspectives which will become more important later in the thesis. First, our connection is *with* the world, it is not to the world and it is not from the world. It is interconnected, not unidirectional. Secondly, our relations are partial, we do not know all of the world, and our interactions do not exhaust all possibilities. Ontologically and epistemologically, our relations are with the reality which we experience. Thirdly, organs are part of us, and, at the same time, are part of the activity and are the means of how we sense the real world. How we sense the world is mediated by physical and psychological tools, and organs are functionally integrated configurations of internal and external resources.

Leontiev and the Kharkov group set out to establish the idea of tool-mediated practical activity as the fundamental, systemic process connecting humans with the objective and subjective aspects of the material and sociocultural world: consciousness is not a subjective addition to human life activity, it is a form of that activity. Integration of consciousness and activity was understood through the emergence of the division of labour.

The activity becomes stratified to the activity, the actions and the operations. These are equated with the levels of motive (the why?), goals (the what?) and conditions (the how?). The dynamic nature of the hierarchal structure of human activity is illustrated in Figure 8.



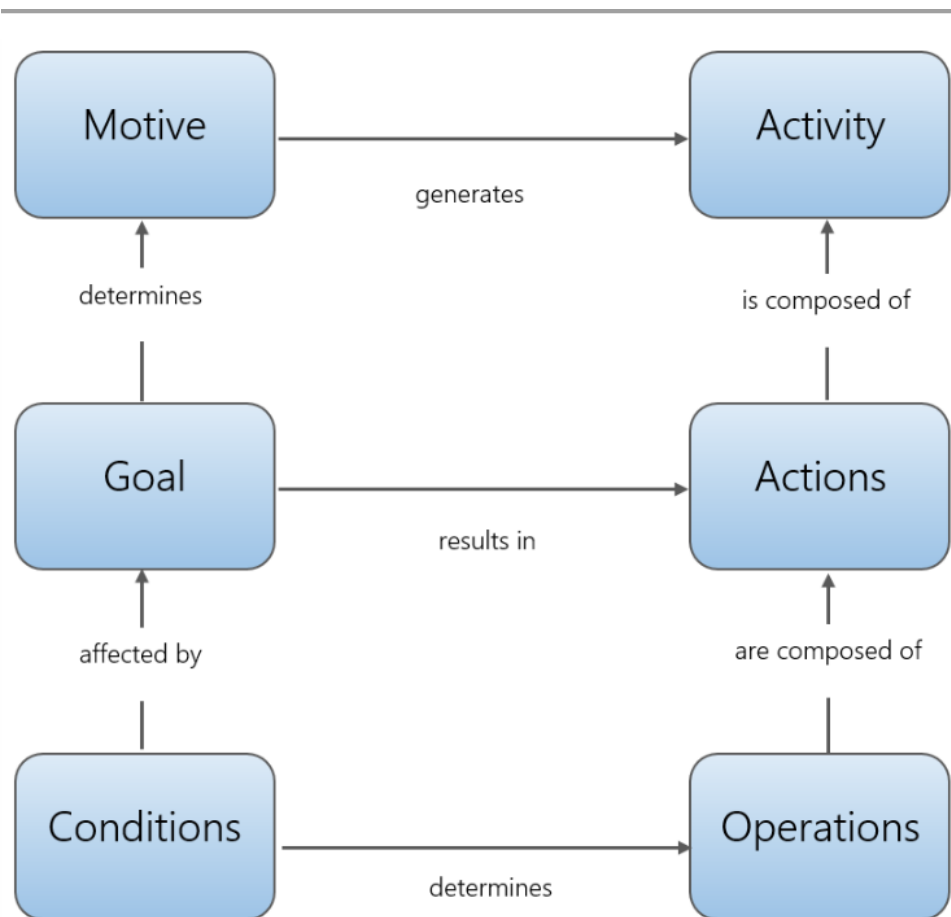


Figure 8: The hierarchical structure of human activity according to Leontiev showing the dynamic relationship between levels (Wilson 2006).

For Leontiev collective activity is driven by a communal motive, which is formed when the collective need meets an object that can fulfil that need. The motive is embedded and embodied in the activity (Engeström, 2000, p. 4). This is illustrated in his famous example of a hunt. In a primeval society the collective *activity* of the hunt is motivated by the need of the community to eat, the *motive*. This is represented by the dyad motive-activity. This collective activity is made up of chains of individual *actions*, by beaters and hunters. An action is oriented towards achieving a specific *goal*, which may or may not be the same as the object related motive. This is represented by the dyad goal-action. To illustrate, the beaters' specific goal is to frighten and chase the prey away from them, which ostensibly is different from the object related motive to catch and kill the prey. The division of labour

shows that the *goals* to which an individual's *actions* are directed are not necessarily identical to the *motives* of the collective *activity*. There are also unconscious, automatic operations driven by the tools available and the prevailing conditions: the terrain, the type of animal sought, the weather, the tools available to make a noise. This is represented by the dyad conditions-operations (Leontiev, 1959, 1978).

All of these actions and operations are considered by Leontiev to be social, including those that are not carried out collectively. Even if people work alone, their work is determined by social and cultural practices, tools, values, and norms. Activities can be individual or collective, but they are always social.

#### 3.2.4 Engeström

Engeström added the concepts of rules, community, and division of labour, and devised the activity triangle (2015). Engeström's general model of an activity system is shown in Figure 9. This model builds on the work of Vygotsky, Leontiev and others, and provides a conceptual map of the major nodes among which human cognition is distributed. The concepts of object and objective will be discussed, and then the categories added by Engeström, the rules, community and division of labour. It is this model that will be used as the basis of the methods, discussed in Section 4.4.

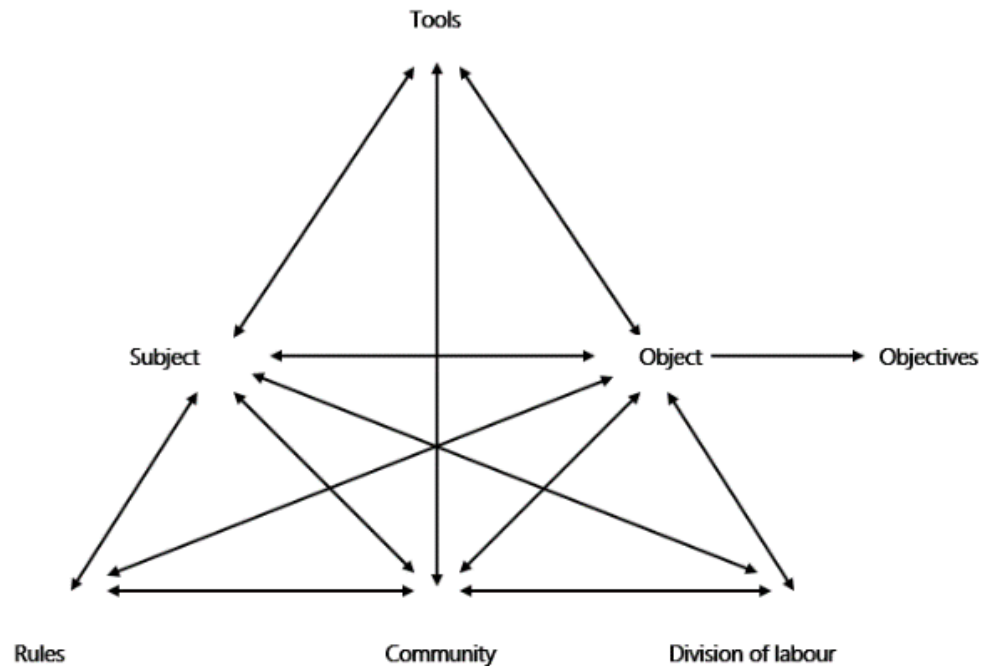


Figure 9: Engeström's general model of the activity system (2000).

#### 3.2.4.1 Object and objectives

The English word “object” does not fully convey the nuances of the Russian object. Following Leontiev (1978) in this thesis the object of the activity is the long-term purpose that gives meaning and motive to the activity. The object represents the satisfaction of a need, the absence or the problem space at which the activity is directed. It is the reason why individuals and groups of individuals choose to participate in an activity, and what holds together the elements in an activity. Humans pursue, reproduce, and potentially transform the object of their activity by means of actions. The objective is the actual result of the activity, which may be a new artefact or cultural tool. There is no guarantee that there will be an objective, or that the activity is robust or sustainable (Hasan, 2010).

#### 3.2.4.2 Rules, community and the division of labour

Engeström added the third level to the activity theory triangle: rules, community and the division of labour. These constructs are the context of the activity, but they also shape the activity through implicit mediation; we

shape our world and our world shapes us. These constructs are pre-existing, independent, ongoing streams of communicative action that are brought into contact, and are integrated into, our goal-directed behaviour. These concepts provide a way to identify how power, control, and culture become enmeshed into everyday interactions, and situates our behaviour in the world (Daniels, 2015; Märtsin, 2012). The activity of the individual cannot exist separately from systems of relations of society (Leontiev, 1977).

In critical realist terms the rules, community and division of labour are mechanisms of society (Danermark et al., 2002, p. 112), and the data are empirical manifestations of these mechanisms. Society is already made, and human activity can only *reproduce* or *transform* it through the *transformational model of social activity* (TMSA) (Bhaskar, 2005, pp. 36–37).

In terms of information systems these mechanisms can also be an artefact. Lee et al (2015) provided the example of longwall miners where the different instantiation of the division of labour in two teams resulted in completely different outcomes, and the division of labour was identified as a social artefact.

In this thesis the constructs will be understood as follows. The rules and norms are the accepted and codified limits on and specification of the activity. The community is the collective aspect of the activity and can be elaborated at different levels: it may be the immediate group, the wider organizational community or society at large. The division of labour has two dimensions. The vertical dimension measures the relative power and status of individuals, through such characteristics as gender, power and age. The horizontal dimension measures the division of tasks within an activity, such as collaboration and sharing.

### 3.3 Critical realism and activity theory

Both activity theory and critical realism recognise and theorise three classes of complexity: the stratified nature of the social world, the social

contextualisation and embeddedness of interaction, and the dynamism of development (Spasser, 1999, p. 1137). Both of them seek to explicate the phenomenon, and provide a holistic analysis of the data. They are compatible in many ways. Engeström identifies that Bhaskar's TMSA and activity theory are essentially the same: they recognise that two basic processes operate continuously at every level of human activities - internalization and externalization (Engeström & Miettinen, 1999). Internalization is the path to reproduction of culture; externalization may reproduce culture, or may, through the creation of new artefacts, transform it. Activity theory and critical realism together have been used in studies in information systems (Allen, Brown, Karanasios, & Norman, 2013) and education (Núñez, 2014; Wheelahan, 2007). Both critical realism and activity theory were included in the methodological theories of a recent information systems text book (Dwivedi, Wade, & Schneberger, 2012). Critical realism is a philosophical foundation which is compatible with an activity theory framework.

#### 3.4 Defining the information artefact

This thesis will draw an understanding of the information artefact from the literature rather than from the data. In information systems, research on the information artefact focuses on the nature and function of information in general. Boell (2017) in information systems, and Gable, Gable, Emamjome, & Bandara (2018) in critical realism in information systems, concur on a taxonomy from the literature on information that comprises a physical stance, an objective stance, a subject centred stance, and a socio-cultural stance.

The physical stance posits that information exists independently of human perception, and research using this stance can focus on the structures and properties, the processes or the transmission of information. In the literature review the studies that focused on broadband generally work within this stance, and identify the function of broadband as the transmission of information. The studies on broadband are generally in the learning

framework, which did not find significant, consistent improvement in learning that correlates with broadband. This thesis will therefore move away from this stance on information.

The objective stance posits that information has an objective reality, and that its meaning could either be independent, or a representation of reality to the observer. The subjective stance posits that information does not exist independently of human perception. The fourth stance is the socio-cultural stance, that posits that information is dependent on the socio-cultural context. The fourth stance is taken in this thesis, as it is congruent to cultural historical activity theory and critical realism. While Gable et al (2018) place this stance within an interpretivist philosophical position, this thesis takes the view that a socio-cultural framework is compatible with a critical realist philosophical position, as discussed in Section 3.3.

The rest of this section elaborates on the socio-cultural stance of information of this thesis. It discusses the socio-cultural context of the information, and then presents the definition of information artefact that this thesis will use. As discussed in Section 2.4.3 the focus of this thesis is on the technology artefact and the information systems artefact. Identification of the information artefact is beyond the resources of this thesis, the work of Nuthall and Alton-Lee provides an appropriate understanding of the information artefact, and will be discussed from Section 3.4.2.

### 3.4.1 The socio-cultural context of the information artefact

Education systems are open, semiotic and recursive: information, symbols and signs are deeply intertwined with learning (Biesta, 2015a). There are two dominant orientations of learning: the cognitive and the socio-cultural (Hodkinson, Biesta, & James, 2008). Cognitive research focuses on the mind and the individual, and socio-cultural situates learning and concept development within society. For the purpose of this thesis the core difference is the boundary of the learning activity: in cognitive theory learning is inside the head; in socio-cultural theory learning is achieved through purposeful activity in the world, and the boundary is outside the

head. As was discussed in Section 3.2, activity theory is a socio-cultural theory, and it is beyond the scope of this thesis to definitively determine the process from information to concept development. This thesis assumes that change in the conceptual knowledge of students in the classroom is induced through purposeful, goal-directed activity supported by teaching staff and peers. Conceptual change occurs in the individual student's mind, but it is induced socio-culturally (Hatano & Inagaki, 2003). This is how, through observation of behaviour, students' concept formation and the construction of knowledge can be observed, and why an understanding of the information artefact is relevant.

Socio-cultural information articulated in the literature is often particular to subjects, eg, mathematics (Chiu & Mok, 2017; Laina & Monaghan, 2014), or tasks or skills, eg, reading (Dynarski et al., 2007; Hou, Rashid, & Lee, 2017). This thesis will follow Nuthall and Alton-Lee in their work on the role of information in general in the construction of knowledge, which is discussed in the next section.

#### 3.4.2 The construction of knowledge and Nuthall and Alton-Lee

A conceptualisation of information in education was developed by Nuthall and Alton-Lee (Alton-Lee & Nuthall, 1990; Alton-Lee, Nuthall, & Patrick, 1993; Nuthall, 2001b, 2001a, 2004, 2007) through their work based on Vygotsky and activity theory. Their work is particularly apposite in information systems because it identifies learning as a function of information (Nuthall, 2007). It must be noted that in this research information is different from knowledge.

A brief summary of their decades of work is that:

1. Students learn what they actively do.
2. Social relationships determine learning.
3. Effective activities are built around big questions.

4. Effective activities are managed by the students themselves. The ideal learning activity, in line with the previous three premises, has the following characteristics:
  - a. It focuses on the solution of a major question or problem that is significant in the lives of the students.
  - b. It engages the students continuously in intellectual work of the kind appropriate in the discipline, which means that the larger question or problem must be broken down into smaller problems that are essential to solving the larger problem.
  - c. It provides teachers with opportunities, as the students engage in solving the smaller problems, to monitor individual students' evolving understanding of the content and the procedures they must carry out.
  - d. It allows students, with experience, to manage their own learning. This is because a parallel goal of the effective learning activity is for the students to internalise the procedures so that they become part of their natural way of thinking.

Knowledge is not tiny bits that can be counted and represented by numbers, but a network of logically interconnected ideas, beliefs, and generalisations, against which new ideas are considered and evaluated (Nuthall, 2007, p. 50). The range of individual experiences of learning among children is theoretically infinite as the individual experience will be unique across multiple continuums.

The theory underlying these procedures is that what students learn from their classroom activities is dependent on the information they extract from their engagement in those activities. Predicting what students will or will not learn from classroom activities depends on identifying the information that they encounter. Individual student learning is a function of the



sequence and timing of the information that the student encounters during their classroom activities. (Nuthall, 2001b, p. 4). Nuthall expressly concluded that this is not a deterministic single variable causality through which the introduction of information results in learning. The student may already know the information, or may disagree with it. The student may be hungry, tired or not interested. The teacher may be unclear, or incorrect. The room may be hot, it may be the last class before the holidays. The information may be in a language the student does not understand. The classroom is never a closed system.

Nuthall showed that the students need to encounter, on at least three different occasions, the complete set of the information they need to understand a concept (ie, as general principles, ideas, facts, procedures, understanding, etc). If the information is incomplete, or not experienced, the students do not learn. When concepts are complex then the relevant information can be fragmentary, only tangentially related, contradictory or simply wrong. Nuthall considers other factors, such as motivation or teaching methods, relevant only to extent that they increase the possibility that students will encounter more relevant information (Nuthall, 2007). Nuthall's categorisation of the concepts and information is discussed in the next section and fully listed in Appendix 1.

Nuthall's model of the social construction of knowledge acquisition (Nuthall, 1997) is shown in Figure 10. This model implies that when a student engages with concept-relevant information, their minds construct a representation of that information in a working memory that remains there for about two days. The student will make links from that representation to prior knowledge and personal experience, and will integrate and evaluate the new experience to conform to their developing understanding of what constitutes coherent and valued knowledge. If a student engages with relevant content on three or four distinct occasions (so that at least three or four different representations of content-relevant information come together in the working memory) then a more permanent representation of the

concept is constructed in the working memory and transferred to long term memory. The student has, as it were, acquired the concept.

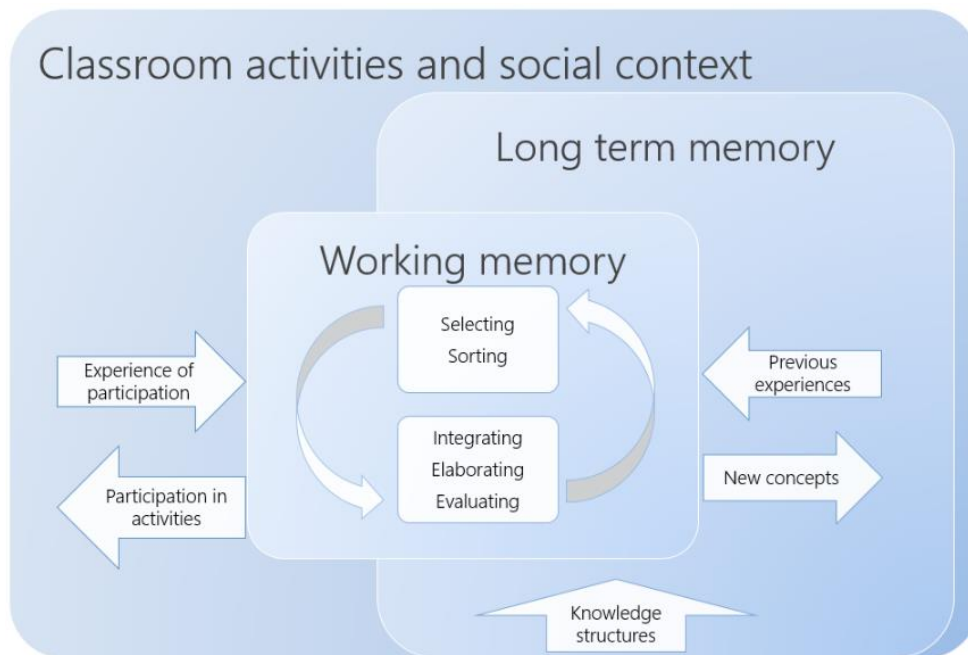


Figure 10: Model of the social construction of knowledge acquisition (Nuthall, 1997, p. 8).

The activities that comprise the acquisition of curriculum knowledge are:

1. Acquiring and clarifying information: while teachers provide much of the new information, senior students often need to acquire information for themselves. It may require searching internal resources, memory, or external sources, knowing who, how and when to ask, or knowing where and how to search. Responding to and asking questions involves retrieving information from memory.
2. Creating associative links: students need to connect new experiences and new information to prior knowledge, either privately or through discussion.
3. Elaborating the content: students need to elaborate on information by making relevant inferences, identifying implications and logical extensions, and dealing with any contradictions or confusions that these create. This may be done through discussion with other students.

4. Evaluating the truth and consistency of information: awareness and information literacy are constantly present in the classroom experience.
5. Developing metacognitive awareness: senior students are experts in classroom activities, and are aware of the components and structural relationships that constitute the classroom conventions<sup>8</sup>, and may have the power to influence their own learning activities.

Nuthall elaborated the conditions in the classroom for the learning of knowledge. The external experiencing of the information and the external practicing of the activity cause the internalisation of the rules and structures of the activity and the connection of new information to prior knowledge to create new knowledge, which in turn externalises the practice of activity and the experiencing of information (Nuthall, 1997; Vygotsky, 1978). Internalisation / externalisation in knowledge creation is a concept accepted in many disciplines outside education (Engeström, 2015; Engeström & Sannino, 2012; Nonaka & Takeuchi, 1995).

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<sup>8</sup> Classroom conventions are different from rules: they are a way of acting in a given setting. In activity theory terms they are institutionalised activities (Cole & Engeström, 1993). They are rarely articulated, are hard to define, and are often not even noticed. There is little academic literature on them, whether termed “classroom conventions”, “social codes” or “meta skills”. Classroom conventions have been defined as the promotion of good manners, such as tidiness of the room, manner of entering and leaving rooms, and is used in distinction to student safety, subject learning and morals (Lewis & Burman, 2008). DeVines, Hildebrandt and Zan refer to internalised norms and values, and opposed them to conformity to authority, social approval/disapproval and reward and punishment (2000, p. 14). However, just because they are hard to define does not mean they are unimportant. Ljusberg (2011, p. 197) states:

...it is of great importance for the pupil to have a pre-understanding [of being in the classroom and his or her relationships with the other students, the teachers and the school] which can help them to interpret and give meaning to the situation.... If the pupil fails it can result in a difficult school experience.

### 3.4.3 Nuthall's categorisation of knowledge and information

Nuthall divided the information the students encounter into *six types of knowledge* which the students are meant to learn from the resources and materials that they are using (Nuthall, 2001b, p. 5):

1. Specific propositions, which include facts, names and descriptions.
2. Definitions, which include definitions of technical or other significant words.
3. Concepts, which involve understanding an idea, or general concept, and can comprise more than one knowledge item.
4. Explanations, which involve identifying how something is or was caused.
5. Principles and generalisations, which are propositions of a more general nature than can be deduced from examples.
6. Procedures, which require the student to carry out a procedure or describe how they would carry out a procedure.

Nuthall used the word “concept” as a generic term to refer to all and any of these six types of knowledge. The concepts make up the intended object of the learning units. For example, an intended object of an activity in School C Year 12 English was that the students were required to understand the characters in a film: their personality, their relationships, how they change, and how they are presented in the film. The students needed to understand the concept of the character.

An item is any item of information that the students encounter to learn these types of knowledge. Students' encounters with information can be as they read, hear or see it, as well as how they express it through speaking, writing or drawing. These can be simultaneous. They are also simultaneously private processes and social activities (Nuthall, 1997, p. 3). The *eight item*

*types of information* that students experience are categorised by Nuthall as (1999):

1. Explicit item of information: information that the student needs to answer the item.
2. Implicit or partial item of information: some of the information the student needs, but not all of the information.
3. Additional item of information or explanation, reasons and examples of the key concepts.
4. Preparatory or contextual information that provides relevant background.
5. Mention or reference to a key word or concept.
6. An activity or procedure that produces, creates, or is intended to lead directly to concept-relevant information.
7. Instructions for relevant activities.
8. A visual or object resources in which relevant information is available but the resource is not the focus of attention.

It is emphasised here that the content of the information is not relevant. Nor is the materiality of the information important; it does not matter whether the information is online or analogue, written or spoken, a painting, statue or film. What is important is the form, ie the internal principle of coherence (Roudaut, 2018). Instructions are instructions whether they are spoken by the teacher, written on the whiteboard, or saved in the course materials.

#### 3.4.4 Operationalisation of the information artefact using Nuthall's types of information

The information artefact is defined by Lee et al (2015, p. 8) as "...an instantiation of information, where the instantiation occurs through a human

act either directly (as could happen through a person's verbal or written statement of a fact) or indirectly (as could happen through a person's running of a computer program to produce a quarterly report)."

Nuthall and Alton-Lee's work is a comprehensive, although not exhaustive, list of knowledge and information types in education, developed over many years of work. This information typology is useful in information systems because it identifies learning as a function of information (Nuthall, 2007), thus the instantiation of the information, and the experience of the information by the student of the information, can lead to learning.

In this research data will be collected on the information artefact, ie, information which is instantiated in the classroom. This includes information which is instantiated directly through a human act and then included in a technology artefact, such as when a student writes lecture notes into a laptop. It also includes information which is instantiated indirectly, such as when a student conducts a search and information is returned on a screen. The data will then be analysed using Nuthall's typology.

A limitation of the use of this typology in this study is that the typology is from an educational setting, and may not be applicable in other organisational settings.

### 3.5 Conclusion

The purpose of this chapter was to establish the foundations of the research. The philosophy of critical realism was established as the basis of this thesis, and its core commitments and methodological implications were discussed. Activity theory was selected as a framework through which to observe and understand the behaviour and activity of the students, through which learning can be understood. A brief history of activity theory was elaborated, and Engeström's general model of an activity system, which will be used in this thesis, was explored. The commonalities between

critical realism and activity theory were identified, which strengthens the foundations of the research.

The information artefact was defined as the information items identified by Nuthall and Alton-Lee. That Nuthall's work is also grounded in Vygotsky's activity theory further strengthens the foundations of the research. The next chapter builds on these foundations, and considers an appropriate research design to answer the research questions.





## Chapter 4 Research design

The literature review showed that the learning, change and power frameworks all identified the potential for future research to be conducted in the classroom, which led to the development of the research questions in Section 2.4:

**RQ1: What is the technology artefact that the students are using in the classroom?**

**RQ2: How do students engage with the technology artefact and the information artefact in the classroom?**

As soon as the classroom was identified as the research site the issue of ethics became salient. Research in the classroom has unique and important ethical considerations which influences the design in all phases, thus ethics shall be considered at the beginning of this chapter. Education systems are open, semiotic and recursive. The students engage with the technology artefact and the information artefact on many levels, and the multiplicity of causal powers and liabilities precludes making certain and precise predictions. Critical realism and activity theory are the foundations which allow analysis on many levels. This chapter builds on those foundations to identify the scope and outline of the data to be collected, and structure methods of data collection that will provide rich data.

## 4.1 Ethics

### 4.1.1 Ethics in education

Educational research impacts students, teachers, schools and their communities, and in this thesis ethics are intrinsic and necessary to every aspect of this study. This research followed the Ethical Guidelines of the New Zealand Association for Research in Education (2010). With regard to the educational institutions the issues that were pertinent to this study were the worthwhileness of the research, the welfare of the school community, and supporting the responsibilities of the institution. Areas which need consideration with regard to the students are informed consent, voluntary participation and the educational progress of the students (McNamee & Bridges, 2002; Mutch, 2005).

The research should be *worthwhile*, not trivial or repetitive. The rights and welfare of the students and other participants should take precedence over the self-interest of the researcher. A school granting research access has requirements and responsibilities that need to be openly acknowledged and respected. The most important issue for this study is that the research took time from regular teaching and learning activities, and this needed to be kept to a minimum to ensure that the students' educational progress was not hindered. This consideration affected the selection of data collection instruments.

### 4.1.2 The VUW School of Information Management Ethics process

The research required ethics approval from the VUW School of Information Management (SIM) Ethics Committee; the application to the VUW SIM Ethics Committee is included in Appendix 4, as is their approval.

Participation and consent forms were developed for students, and are included in Appendix 4. Participation and consent forms were also developed for the parents / caregivers of the students. Under the VUW Human Ethics Committee policy 16-year olds can give their consent to participate without their parents' / caregivers' permission, and the research

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was aimed at students 16 and over. However the researcher considered that the students may be under 16, or may have wished to discuss the research with their parents / caregivers, and so a set of forms for parents / caregivers was developed. In the end all of the students were 16 or over.

Participation and consent forms were also developed for the teachers, and are included in Appendix 4. Permission was also sought from the Principals to conduct research in their schools; they were given teacher participation forms and modified consent forms to reflect the nature of their position.

## 4.2 Case study

Research in the field lends itself to an in-depth ethnographic study of a single classroom or case studies of multiple classrooms. The case study approach was selected for a number of reasons. The first consideration, that the scope, as to both the extent and the quality of the phenomenon, is unclear, is derived from the research questions, and the methodology. There is a large exploratory component in the research questions. It is not known what technology the students are using nor how they are using it. This research is seeking to find out the everyday use in the classroom, not in an experiment. It is seeking to find out whether there are similarities or differences between urban and regional schools, private or public schools, between literacy and numeracy subjects. Benbasat, Goldstein and Mead (1987, p. 370) state,

A case study examines a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities (people, groups, or organizations). The boundaries of the phenomenon are not clearly evident at the outset of the research and no experimental control or manipulation is used.

Case research is appropriate for both information systems (Benbasat et al., 1987) and critical realism (Tsang, 2014; Wynn & Williams, 2012).

The second and third reasons derive from practical considerations, from the point of view of the schools and the researcher. The ethnographic approach can be intensive: Nuthall and Alton-Lee conducted their research over one year, plus an interview for a post-test the following year, using microgenetic methods and collecting data by attaching microphones to every child and using cameras, amongst other methods. Their research was invasive over a long period of time. Senior secondary students in New Zealand have internal assessments throughout the year and external examinations at the end of the year, which are highly important for tertiary education and job seeking. After discussing the different methods with teachers it was felt that case study would be less intrusive. Thirdly, as the thesis was conducted part-time it was impractical to use a method that required a large time commitment in the classroom.

Once case study was selected as the method then the research design could be developed. The next section considers the issues of the population and case selection. The unit of analysis, informed by activity theory is identified, which allows the design model to be created, which will be discussed in the next section.

### 4.2.1 Population

The population of the study was identified as senior secondary school students in New Zealand (Section 2.4.2). The defining characteristics of the population are activity and age, and this population is large and widely distributed throughout New Zealand. This thesis is using activity theory which seeks to understand activity within sociocultural learning, so the cases must be of a collective activity, which is satisfied by studying the students in the classroom in the secondary schools. This population is still broadly distributed throughout New Zealand.

### 4.2.2 Case selection

Ideally a range of schools would participate, with possible characteristics of the schools being urban / regional, private / public; and characteristics of

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the classes being numeracy / literacy subjects. In reality the sample was defined by two limitations. The first is the limitation of the resources of the researcher, such as the researcher not speaking te reo Māori which eliminated Kura Kaupapa Māori<sup>9</sup> from the study, and the cost of conducting research outside the local region which restricted case selection to the Wellington region. The second limitation was the difficulty in gaining access to the schools. The cases ultimately comprised the 11 classes in the schools that agreed to the research (Section 5.1.1), however a reasonable spread across the characteristics was achieved. An ethical issue arose over timing of the research. Senior students undertake external examinations in the fourth term, and the end of the third term and the beginning of the fourth term are often used for revision. In order to minimise disruption to the students' educational progress the observation periods were timed for the first half of the school years.

Two issues of self-selection arose. The first was with refusal: eight of the thirteen schools approached did not consent to research. The schools that did consent were mid to high income schools. They were well resourced with technology and libraries, and the students were also generally well resourced. This is a limiting factor of the research.

The second issue is with acceptance. The Principals did not select teachers but disseminated the request for research to the teachers who self-selected. There was the potential that this could skew the sample, eg, if only teachers who were experienced with and promoted using technology in the classroom participated then this may not be the norm across the schools. There were two mitigating factors. First, the participating teachers were in a broad range. Only two of the eight participating teachers were on the technology team of their school, and of them only one really considered themselves to be technology-savvy. At the opposite end of the spectrum one teacher considered themselves as not technology-savvy at all, and was interested in knowing how to make valuable use of the technology that was

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<sup>9</sup> Kura Kaupapa Māori are Māori-language immersion schools.

obvious and constant in the classroom. One teacher participated because they valued research for its own sake rather than the topic. Overall the teachers who participated were highly professional and were confident in their pedagogical ability. The second mitigating factor is that the unit of analysis, which is discussed in the next section, is not the teacher but the activity of the students in the class engaged in learning.

### 4.3 Unit of analysis

In the literature review there are many different units of analysis, both in the realm of the social artefact, from the education system to individual students, and in the realm of the technology artefact, from a single technology to the internet. The importance of the unit of analysis is illustrated in the perennial example of water: analysing the elements of hydrogen and oxygen will contribute little to an understanding of ocean currents or a swimmer's hydrodynamics.

An important purpose of Vygotsky's work was to develop a new method to account for his understanding of development, and this depended on reconsidering the unit of analysis. Around 1930 he wrote (1978, p. 47),

In our view, an entirely different form of analysis . . .  
relies on the partitioning of the complex whole into units.  
In contrast to the term 'element,' the term 'unit'  
designates a product of analysis that possesses all the  
basic characteristics of the whole. The unit is a vital and  
irreducible part of the whole.... In precisely the same  
sense, the living cell is the real unit of biological analysis  
because it preserves the basic characteristics of life that  
are inherent in the living organism.

The unit of analysis is the smallest object of analysis in a study, but it needs to be of a level where comparison and generalisation can be made. The individual is not the correct unit of analysis in sociocultural research because properties of the individual, such as IQ and motivation, are

inappropriate. The appropriate level is the process of the sociocultural *activity*, involving active participation of people in socially constructed practices (Matusov, 2007, p. 320). In this research the unit of analysis started as the class of students as a whole engaged in learning. The observations showed that classrooms are dynamic, and students can engage in different tasks at the same time and over the period of the lesson, so in data analysis the unit may range between the whole class watching a film, to a small group of students discussing a character, to individuals writing their essays. It is the activities, actions, and operations that are being explored in this thesis, as they are determined by social and cultural practices, tools, values and norms, whether they are carried out individually or collectively (Leontiev, 1959, 1978).

#### 4.4 Modelling the research design

Both critical realism and activity theory are premised upon a deep understanding and explication of the phenomenon. The research design aims to identify the structure of the activity system and the concepts and relations in it, and will use the Activity Oriented Design Method (AODM) (Mwanza-Simwami, 2011; Mwanza, 2002). This was developed to explicate Engeström's model of the activity system (Section 3.2.4), and is widely used to investigate technology enhanced learning and design (Greenhow & Belbas, 2007; Murphy & Manzanares, 2008; Yamagata-Lynch, 2009, 2010). AODM comprises six stages, from the research design to communication of results. The model is particularly aimed at early researchers, as its purpose is to break down the phenomenon into manageable parts, and encourage the researcher to consider a wide range of possibilities of interpretations and relations. This model was useful in the research design stage, however, for analysis and presentation of data it relies on inductive reasoning, and this research moved to the abductive / retroductive reasoning of critical realism.

The first step is to understand the particular phenomenon with Engeström's activity triangle. This is done by converting every node of the activity

theory triangle to a question; this ensures that every part of the activity theory triangle is accounted for. For example, the general node *Rules* asks the question, *Are there cultural norms, rules or regulations governing the performance of the activity?* The questions identified in Stage 1 are then mapped onto an activity triangle to create a visualisation of mediated learning, presented in Figure 11.

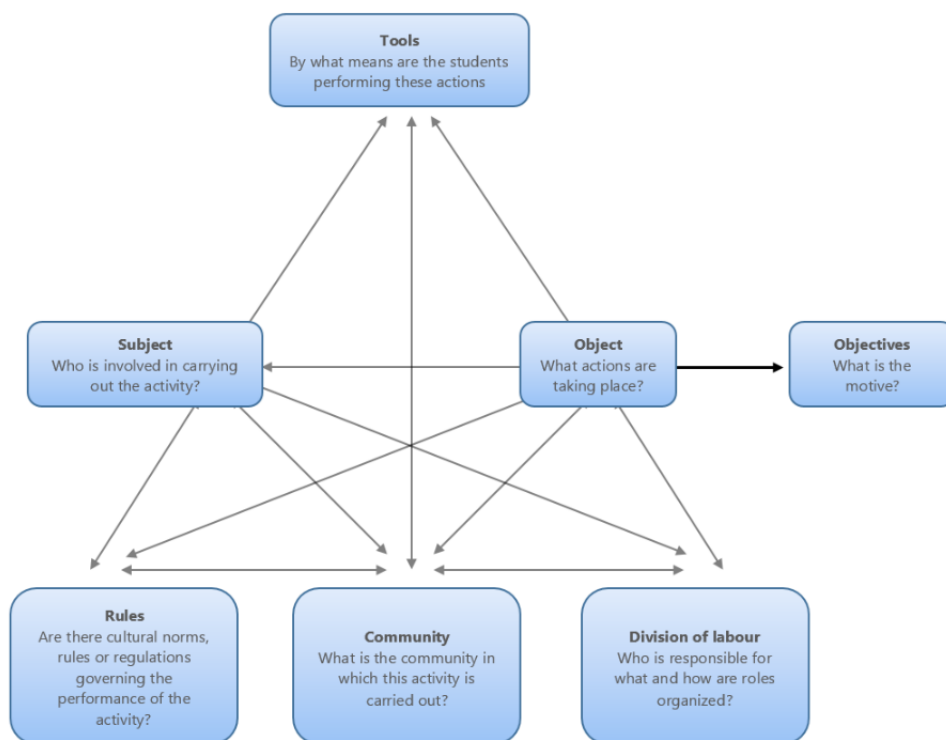


Figure 11: Questions mapped to the nodes of the activity triangle.

The researcher then anticipates the many and diverse possible answers. For this thesis possible rules, norms or regulations were thought to be: whether the use of IT was mandatory or voluntary; rules about when the student can use IT; social norms around responding to mobile phones / social media / alerts that may be constrained in the classroom. This is shown in Table 3.



<b>Node of the activity theory model</b>	<b>Questions to ask to identify components of activity</b>	<b>Possible answers in this study</b>
Activity	What sort of activity am I interested in?	How does technology mediate student learning?
Objective	Why is the activity taking place?	To achieve specified learning within the curriculum; to acquire a new skill or insight, complete a school task.
Object	What actions are taking place?	Learning.
Subjects	Who is involved in carrying out the activity?	Senior secondary students (and teachers).
Tools	By what means are the subjects performing this activity?	Technologies the students are using to mediate their learning: hardware, software, broadband.
Rules and regulations	Are there cultural norms, rules or regulations governing the performance of the activity?	Mandatory use or voluntary use of IT. When can use IT. Social norms, eg answering mobile phones.
Division of labour	Who is responsible for what and how are roles organized?	Teacher prepares material, coordinates activity and assesses performance; students work individually and collaboratively, participate in production of material; applications coordinate group activity, manage work.
Community	What is the community?	The class, the school, virtual communities.

Table 3: Mwanza's Eight-Step-Model (2002) defining and describing the nodes on the activity triangle.

Through this process the methods to answer the question also becomes apparent. For example, a possible answer is that there are mandatory rules about when the technology can be used. As rules are likely to be created or enforced by the teachers then a method to uncover this answer is to interview the teacher. Another possible answer to the same question is that there are social norms governing the use of technology, which would be known and implemented by the students. Methods which could uncover this answer are a student questionnaire or observation of students' actions.

Mwanza identifies that these questions are appropriate for a pilot study, and can be refined for later cases. From the pilot study it was found that the questions were appropriate although not quite comprehensive, which is discussed further in Section 5.1.4.

The next step is to uncover the best method of collecting answers to these questions, and neither activity theory nor critical realism is canonical. A continuing thread in choosing the methods was considering the ethics of conducting research in education, eg to respect the welfare of the student and not interfere with learning. The next section discusses the methods that were selected.

### 4.5 Data collection

Working with Engeström's activity theory triangle (Section 3.2.4) and the questions identified through Mwanza's model (Section 4.4) each concept was mapped to a method for the collection of data. The best methods of data collection were considered to be observation, student questionnaires, teacher interviews, documents and server logs. The mapping of the constructs to the data collection methods is shown in Figure 12. The individual methods are discussed in the next sections.

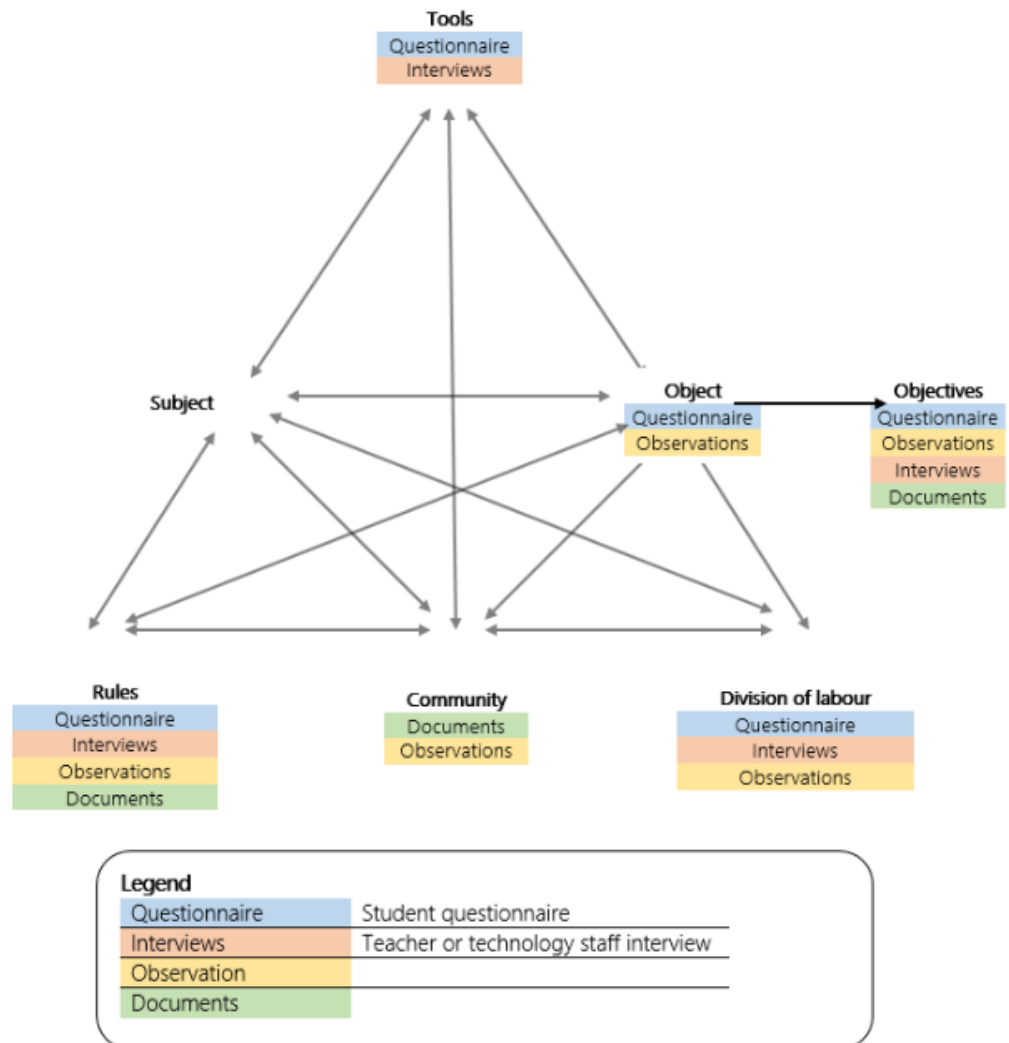


Figure 12: Map of data collection methods to theory constructs.

#### 4.5.1 Observation of the activity

In activity theory a dominant data collection method is observation. Activity theory derives from psychological theory in the 1920s and 1930s, when it was impossible to observe internal, psychological forms directly. Vygotsky instead argued that the psychological could be inferred from the behaviour of people. Vygotsky posited that learning is a sociocultural activity, involving the active participation of people in socially constructed practices; their actions are shaped by the participants' ongoing interpretation and construction of stimuli and their situation. Thus internal (psychological) changes can be identified through observed external,

executing actions. Observation is able to capture the broad understandings of the activity *in situ*, the small nuances of the stimuli and situation, and their changes over time. Observation was considered appropriate for almost all nodes of the activity theory triangle.

Because of the ethical consideration to not interfere with students' learning this research did not consider participant observation. This study follows Nuthall's microgenetic approach (Nuthall, 2012a, 2012b), in spirit if not in form, as this research is on a much smaller scale. The microgenetic approach is a running record of an activity. Observations start at the beginning of an action and end when the task is concluded or reaches a stable state. Observations are timed, so notes are taken every 10 minutes, for example, and dense relative to the rate of change of the learning. The key in the microgenetic approach is to have a timeline showing what the students are doing, saying, or writing at a particular time. The purpose of microgenetic observation is to provide data on what students know, and 'how they got there' (Brock & Taber, 2017, p. 46).

A limitation of this method in this study is that the unit of analysis in this study was the activity of the entire class, which in the cases was between nine and 27 students. Even when the unit of analysis became smaller, eg, students in a small group, not all of the students can be observed all of the time. Even Nuthall's microgenetic research only focused on six students who represented different levels of learning achievement. However, the research question is broad and observation of the classroom can identify broad, collective activities, and the observations will be supported by other data collection methods.

#### 4.5.2 Student questionnaires

The research is focused on the activities of the student (Section 4.3). In order to find out what the students do with technology in the classroom it seems reasonable to ask them. A question is an epistemic referential question that is intended to provide contextual information about actions, goals, relationships and events (Peterson, 2000). The questionnaire was

considered appropriate for all nodes of the activity theory triangle. While generally researchers consider that answers to questions are meaningful there are three qualifications to this statement. First, it is now generally recognised that the answers provided are not neutral, and are constructed at the time the question is asked and are influenced by the question and previous questions. Secondly, the mode of delivery of the question, whether written in a questionnaire or asked in an interview, on paper or electronic, affects how the question is answered. Thirdly, the questionnaire must be congruent with the ability of the participant to answer it. Given these constraints the questionnaires were developed using Peterson's work on *Constructing effective questionnaires* (2000), which discusses construction of questionnaires, and the construction and wording of questions. The student questionnaire is attached in Appendix 2.

#### 4.5.3 Interviews of the teachers

While the research is focused on the students it is the teachers who have the power in the classroom for establishing the rules and the objective of the activity, and often the actual tools being used, so interviews with the teachers were considered appropriate. The interview checklist was also developed with Peterson's approach (2000). The interview was semi-structured, to obtain full information about these nodes and to allow for unexpected data. The interview checklist is attached in Appendix 2.

#### 4.5.4 Documents

Two types of documents were collected. First were documents that illustrated the situation of the activity, ie, the nodes of the rules, community, and objectives. For example, there were posters in the classrooms of rules around use of technology. The second were documents which related to the tool and to the information artefact, eg, posters in the classroom on the subjects the students were learning. These documents were treated as complete units of data, and were not used for textual analysis.

### 4.5.5 Server logs

Server logs were initially intended to be part of the third leg of the triangulation: what students are supposed to do (from the teacher interview), what students say they do (from the questionnaire), and what students actually do (from observation and server logs). Server logs theoretically seemed like a promising source (Klassen & Smith, 2004), however they were impractical to obtain. Only two of the schools had a technology department, and in the pilot study it took hours to obtain the logs for a single student for a single activity. In another school the researcher was scheduled to pick up the logs for a morning session after school, but, unknown to the teacher, the logs were only kept for the immediately preceding lesson. In the end the little data collected was neither sufficient nor comparable, and were not used.

## 4.6 Conclusion

The literature review pointed towards using methods that could explicate a complex, multidimensional phenomenon, and case study was identified as the most appropriate method. The Activity Oriented Design Method provided an analytical tool that enabled the phenomenon to be parsed into manageable segments, and uncover the data collection instruments. The next section reports on the participants and the materials, and the data that was collected.

## Chapter 5 The participants and materials

The previous chapters laid the foundations of critical realism and activity theory, and built the structure of the thesis through the research design. This chapter populates the structure by identifying the participants and their relation to the data collection methods, describing how the data was prepared for analysis, and outlaying the coding for the data.

### 5.1 The participants and the materials

This section identifies the participants, the data collection instruments relevant to the participants, and details about the preparation of the data. Background information on the cases, including the technology and the subjects of learning of the students, is presented in Appendix 3.

#### 5.1.1 The schools

Four schools consented to participate in the research. The researcher had a relationship with the pilot school, a supervisor had a relationship with another of the schools; this enabled the researcher to meet with the

Principals<sup>10</sup> of these schools. Thirteen other schools across the Wellington region were cold called and three showed interest in the research. In all cases the researcher presented to the Principal and sought and gained formal permission to conduct research in the school. The Principals of the three unknown schools noted that they receive many requests for research as Victoria University of Wellington has a School of Education, and they were interested in the topic as the use of technology in the classroom was of concern to themselves and the Boards of Trustees. One noted that the impact of the research on the students was a factor in their decision, and all of them explicitly required ethics approval for the research.

The schools covered the range of sought characteristics. Two were private, one was a State school, and one was a State-integrated school (the differences are elaborated in Appendix 3). Three are urban schools, one is regional. One was connected to fibre under the UFB, two were connected to fibre through other providers, and one had ultrafast broadband but not over fibre. The cases are presented in Table 4.

As well as the teachers and students discussed below, the technology staff were interviewed if the school had any, and librarians if they were responsible for lending devices to the students. These interviews contributed data to the concepts of tools and rules.

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<sup>10</sup> In New Zealand there are many titles including Principal, Headmaster and Head Teacher. For reasons of conformity and to keep the identity of the schools confidential in this study the participants will all be referred to as a Principal.



School	Character	Broadband	Class	Total number of students	Number of consenting students	Number who completed questionnaire (online)	Percentage of consenting students who completed the questionnaire	Number of lessons observed	Dates of study
School A	Urban	Fibre	Year 13 History	24	24	24	100	12	5-6/2015
	Private	Not UFB	Year 13 Accounting	13	13	13	100	9	
School B	Regional State	Fibre Not UFB	Year 13 History	22	21	14	66	5	3-5/2017
			Year 12 History	15	15	15	100	5	
			Year 13 Statistics	29	27	14	52	6	
School C	Urban	No fibre	Year 13 Media studies	15	13	10 (10)	87	5	5-6/2017
	Private	Cable	Year 12 English	22	21	17 (4)	81	5	
			Year 13 Statistics	16	16	9 (9)	56	6	
School D	Urban	Fibre	Year 13 English	9	9	9 (0)	100	5	5/2017
	State integrated	UFB	Year 13 Chemistry (1)	13	13	10 (0)	77	4	
			Year 13 Chemistry (5)	13	13	11 (0)	85	5	
total			11	191	185	145 (23)		67	
average				17				6	
percentage					97 <sup>11</sup>	78 (12) <sup>12</sup>			

Table 4: Participants in the study by school, class, students, lessons; data by questionnaire and observations.

<sup>11</sup> Percentage = consenting students / total number of students

<sup>12</sup> Percentage = students who completed the questionnaire / consenting students

### 5.1.2 The teachers

Eight teachers consented to participate in the research. The Principals did not select teachers but disseminated the request for research to the teachers who self-selected. In one of the cold called schools there were no teachers who were interested in participating and this school was omitted from the study. In each of the other schools two teachers consented to participate, one in a numeracy subject, eg, Statistics, and one in a literacy subject, eg, English. Semi-structured interviews were taken with the teachers, which were recorded. The interview checklist is included in Appendix 2. These interviews contributed data to the concepts of tools, objectives, rules, and division of labour.

### 5.1.3 The classes

In total 11 classes were observed, which are listed in Table 4, which shows the participants by school, class and students. In total 67 lessons were observed. In the pilot study the observation period was four weeks and the average number of lessons observed was ten. In the rest of the study this was reduced to two weeks with an average number of lessons of five. Data from the observations contributed to all of the concepts in the activity theory system.

This study used the microgenetic method of observation (Section 4.5.1). To avoid interfering with the learning of the students the researcher sat at the back of the class if possible, and to the side rear if not. This gave an overview of the whole class and their screens. A sample of an observation schedule is presented as Figure 13.

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Code	Time	Observations	Notes	Comments
Rules Object Tools	10.15	<p>T→C "please turn to big screen (projector→ whiteboard), not your little screens, big (laptop) and little (phones)</p> <p>NEW TASK</p> <ul style="list-style-type: none"> <li>• Going through slide</li> <li>• This is the time for you to think "to what extent, to connect, analyse, make a judgment is level 3 thinking, but you can do it at level 2</li> </ul> <p>S "is this on refill or Google Docs?</p> <p>T "I don't mind refill or device</p> <ul style="list-style-type: none"> <li>• 3 students take refill</li> </ul> <p>T "this is not a yes/no answer, this is a personal response. Work individually</p>	<p>This task builds on previous task</p> <p>External standards NCEA level 2 and 3</p>	<p>Internalisation of previous task</p>
Info	10.17	<p>S<sup>3</sup> asks S<sup>1</sup> for definition of repenting</p> <p>S<sup>3</sup> googles for definition of cowardice, then thesaurus online</p>		
	10.20	<p>Quiet writing</p>		

Figure 13: An example of a transcribed and coded observation schedule.

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Figure 13 presents a transcribed and coded sample (where T is teacher, C is class, S is student). The four columns on the right were completed in the classroom. The observations were timed for 10 minutes, but exceptional events were noted at other times. The data in *observations* and *notes* was denotative: *observations* record what is observed, *notes* contain explanations from outside the observed event. In this sample the observed statement by the teacher “level 3 thinking” is explained in the *notes* that it refers to the National Certificate of Educational Achievement (NCEA)<sup>13</sup> level 3. *Comments* is the researcher’s opinion at the time of the observation. These were recorded on the observation sheets in a different coloured pen and to the side. This is because events can have multiple explanations, and while the researcher may have an idea why an event may be perceived there can be other equally valid explanations, both instead of or as well as the interpretation that is applied (see judgemental rationality in critical realism Section 3.1.1.3). The column on the left is coding to the nodes of the activity theory triangle, or to the IS artifacts, and were applied after transcription. Each timed section could have multiple codes.

Observations also included drawing the seating arrangements. An example of a seating arrangement, with key, is shown in Figure 14. Seating arrangements are indicative of the activity theory triangle node division of labour.

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<sup>13</sup> NCEA is the National Certificate of Educational Achievement, the national qualifications for secondary students in New Zealand. See Appendix 3 for more detailed explanation.

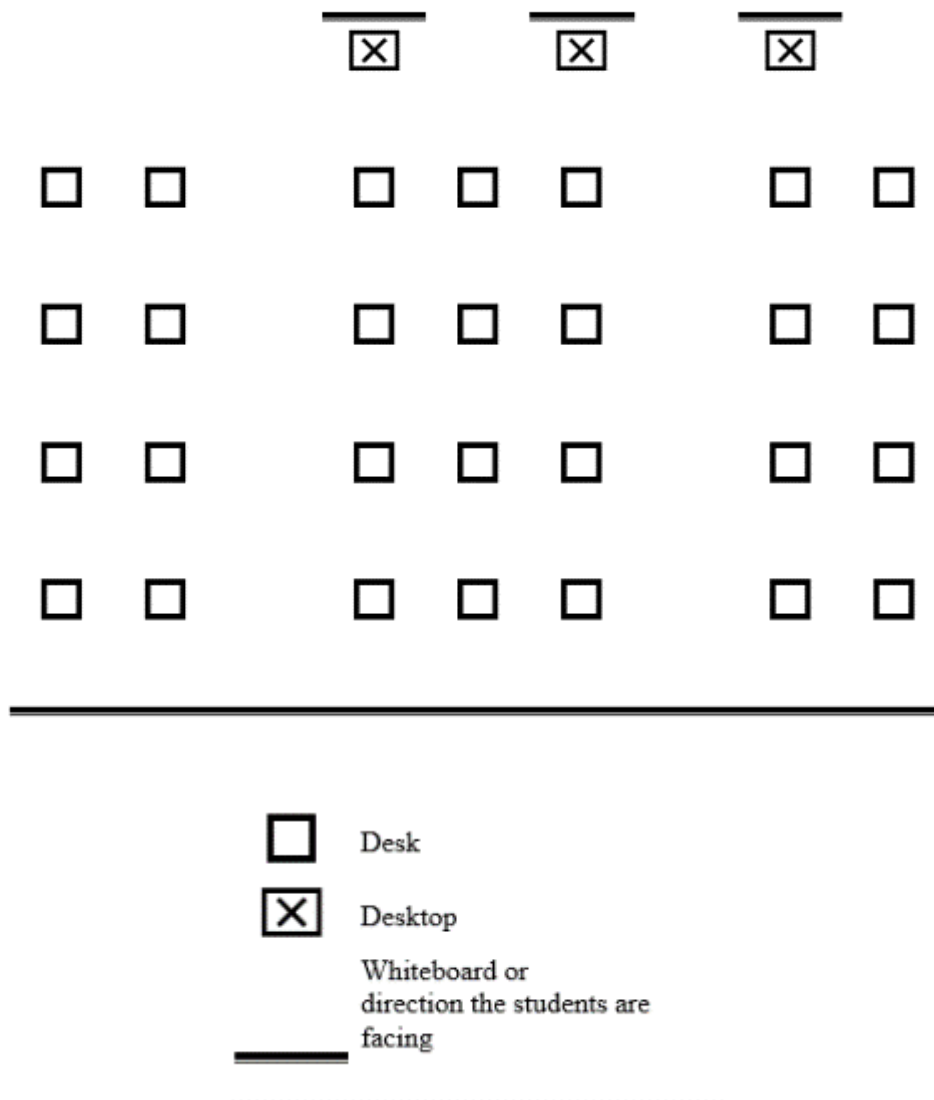


Figure 14: Figure of paired seating with a bank of laptops against the back wall.

#### 5.1.4 The students

There were 191 students in the classes. The researcher presented the research and distributed information sheets and consent forms at the beginning of the first observed lesson. This was kept to 5 minutes during class, including questions, to keep the time away from learning at a minimum (see Ethics, Section 4.1), and the researcher was available for students to question after the lessons. There was a concern that this would not be sufficient time for the students to make an informed choice. However, in all the classes the students asked sophisticated questions, including about possible Hawthorne effect, and evidenced that they had

sufficient agency to provide informed consent. It was emphasised to them that the research was completely voluntary and they could change their minds and withdraw from the study. If students chose not to participate their customary seats were noted or they were identified at the beginning of subsequent classes. No observations about them were made and they did not participate in the questionnaires. In all 185 students consented to participate in the research, and no students withdrew from the study.

One hundred and forty-five questionnaires were completed by the students. The questionnaires were administered at or near the end of the four or two-week observation period, and were generally administered before and into the lunch or recess break. Students were offered snacks (apples, biscuits and chips, of which the apples were most popular) as a thank you for their time. Most students completed the questionnaire within three minutes. In each class three to five students spent up to ten minutes completing the questionnaire, and in total three students spoke directly to the researcher. While the questionnaire asked about the experience of the just completed lesson the responses could not be linked to the students in the observation as the students' names were not known during observation.

There are two important notes about the questionnaires that relate to the context of the students' learning. First, the questionnaires were generally taken at the end of a double period, which is about 2 hours long. This is important because in such a long lesson the students undertake a number of tasks, can move location, and can use non-digital technology.

Secondly, the students in the different cases were at different stages of learning. The observations were over approximately 2 weeks. None of the assessment units were started and completed in this time. Thus some students were at the beginning of the assessment, which requires wide and general understanding. Some were in the middle, requiring refining their understanding, and some were at the end, requiring writing up their assessment work. It can be seen from these broad descriptors that the students will be undertaking different tasks at different stages of their

learning; that they will have different information needs, and that their purposes with the digital technology will be different.

The final version of the questionnaire is included in Appendix 2. The questionnaire changed over the course of the study in a number of ways. First, the pilot study was conducted in 2015, the other studies in 2017. The introductory section includes a rapport question, shown in Figure 15.

2. In a perfect world which device(s) *would you use* to access the internet? You may tick more than one box.

a.	Smartphone	<input type="checkbox"/>
b.	Smartwatch	<input type="checkbox"/>
c.	Desktop	<input type="checkbox"/>
d.	Laptop	<input type="checkbox"/>
e.	Tablet	<input type="checkbox"/>
f.	Microsoft HoloLens	<input type="checkbox"/>
g.	Other (please specify)	

Figure 15: Student questionnaire, question 2, *In a perfect world which device would you use to access the internet?*

For the pilot study the future technology of 2015 was Google Glasses. These no longer existed in 2017, and so the future technology question was changed to Microsoft HoloLens. In itself this is a vignette of the speed of the change of technology and the difficulty of predicting future technology.

Apart from the change in the future technology question there were three other ways the questionnaire changed over the course of the study. First, questions were changed if it was apparent that they were not clear to the



students. These were of the wording of the questions rather than of substantive issues. However it became apparent that terms that the researcher thought were clear, and had been used by educators and researchers (Sweeney, 2012), were not understood by all of the students. For example, for this same rapport question, a few students asked what a laptop and a tablet was, and one asked what a desktop was. The speed of change of technology is again relevant. Since 2012 hybrid 2-in-1 tablets have been developed which have both touchscreen and keyboard. While Microsoft describes the Surface as a laptop, it is possible to also describe it as a tablet. This is another early indication that while the material aspects of the technology are becoming diverse and diffuse the formal aspects endure. While the students were completing the questionnaires the researcher stayed in the classroom and clarified any questions of the students.

The second change arose because the data in the pilot study, specifically answers to the questionnaires, talking to students in the pilot study, and observation of the students' practice, illuminated two limitations of the questionnaire. First, it privileged the technology. It assumed that the activity was using the technology in the classroom, and that only if it did not help the students to achieve their objective then other media were available. However, the pilot showed that students may decide not to use the technology even if it helpful because they preferred another media. An illustrative student response is, 'technology definitely benefits learning but I prefer to read on paper'. This was reinforced in an observation that students asked to move an exercise from the digital to paper, which is discussed in Section 6.1. Secondly, it neglected the students' agency and did not provide sufficient opportunity for them to voice their opinions. Two new questions were added for the remaining three schools, Question 12 and Question 13.

Question 12 asked if the student preferred to perform actions electronically or on paper, the options being to take notes, read information that my teacher has collected, develop my plan for written work, and write up my work. The second option was phrased as 'read information that my teacher

has collected' to focus on academic papers. Question 13 was open, allowing the students to give a short answer on their broader opinions; it asked, 'In your opinion, does going online help you in your learning? Why?'

The third change arose from the observation in School C that the students were frequently on the Google platform, and in this school and School D the questionnaire was offered on paper and online through Google forms. The number and percentage of students who completed the questionnaire online in School C is presented in Table 4 in Section 5.1.3, while no students in School D completed the online questionnaire. While it was hoped that this variation could contribute some data to provide insights as to method (eg, online questionnaires in/decrease response rate, students write more in short answer questions online) or the phenomenon (eg, given the option more students in Private schools will work online in comparison to State-integrated school, or vice versa) there was insufficient data and contextual information to draw any meaningful conclusions. For the rest of the thesis reference to the questionnaire will include both paper and online responses.

## 5.2 Preparing the data

Preparing the data is the first step of the methodological model in critical realist research, RRRE, discussed in Section 3.1.2. This is comparable to Yin's (2016) methods of compiling and disassembling the data. This section discusses the methods used to prepare and resolve the data, the substance of which is presented in Chapter 6.

### 5.2.1 Initial steps

The initial step of data preparation is compiling and organising the data by transforming it into language-based or visual data. Preparation of the data for analysis depended on the data collection instrument. The observations were typed up, as shown in Figure 13, in Section 5.1.3. The teacher interviews were transcribed. The questionnaires from School C were collated in Google Forms. Once it was discovered that the data could not

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easily be extracted from Google Forms the questionnaires were collated in Excel. The students' questionnaires were not linked with the observation as the students' names were not taken during observation. The documents were scanned.

To ensure consistence and accuracy of the data the distinction between denotative and connotative notes that was followed in the data collection (Section 5.1.3) was continued when compiling the data. Initial labelling of the data used the constructs from activity theory, as described in the research design (Section 4.4).

### 5.2.2 Disassembling the data

Once the data has been compiled into records in a useful order the next step is to disassemble the data into smaller pieces through coding. This can be done through open coding, or using *a priori* codes (Yin, 2016). A form of open coding is grounded theory, an inductive approach to theory development, whereby the data is disassembled into codes, the codes are collected into concepts, which support categories which are used to generate a theory (Glaser & Strauss, 1967). The components are then linked through axial coding, selective coding or process coding to describe a series of actions that occur over time and space. While grounded theory has been used in critical realist studies in information systems (De Vaujany, 2008; Volkoff, Strong, & Elmes, 2007) this researcher finds it difficult to reconcile grounded theory with critical realism on two points. First, grounded theory deals solely in the domain of the empirical and identifies theory from events in that domain, whereas critical realism uses events in the domain of the empirical to identify underlying generative mechanisms which are in the domain of the real (Section 3.1.3). In grounded theory the event is the totality of the phenomenon; in critical realism the event is merely that part of the phenomenon which is able to be empirically measured. Secondly, in inductive reasoning the theory is developed from the data to explain the event and its relations and actions over time, and is testable (Yin, 2016). In critical realism theory is contingent and fallible, and

are descriptions of the structures and mechanisms which generate the observed phenomenon (Section 3.1.3.2).

Another issue with coding through grounded theory in this study is that the purpose of coding is to move methodically to a slightly higher conceptual level. Yin uses the analogy of the branches of an upside down tree (2016, pp. 197–198), where the thin branches at the bottom are the most concrete concepts which are the open codes. Inductive reasoning abstracts concepts from the concrete codes which pull together the larger group of related items below, which is represented in the analogy by the thicker trunk. In this study there are two pre-set, *a priori* codes, one derived from activity theory and the other from Nuthall's information items, but both of these are at the level of abstract categories. Following Yin (2016, p. 196) this study will use the pre-set codes that are high level abstract categories for an overall understanding of the data; for the more detailed concepts and relationships the study will not code but use derived notes to disassemble the data (Yin, 2016, pp. 199–201). The next sections will identify the pre-set codes that were used in the study, and then discuss the derived notes.

#### 5.2.2.1 Coding

The data collection instruments were structured around activity theory triangle concepts. These nodes are the category level of codes, being the subject, the tool, the object, the objective, the rules, the community, and the division of labour. Figure 13, in Section 5.1.3, is an example of an observation which has coding from this activity theory set of codes.

The second set of pre-set codes is Nuthall's information coding categories (2001b), a complete set is contained in Appendix 1. Table 5 presents Nuthall's coding of information items and provides examples of such items from the data. The categories code different information items. There are eight standard codes for information items, these are highlighted in orange in Table 5. Each standard code may have up to six sub-codes; in the table a relevant sub-code is highlighted in green. The description of the sub-codes can be quite long and explicit.

	<b>Examples from the data</b>
<b>Explicit item of information:</b> information that the student needs to answer the item.	In School A Year 13 History the students were given accounts from both Māori and non- Māori of the battle of Ruapekapeka in the Northern War.
<b>Implicit or partial item of information:</b> some of the information the student needs, but not all of the information.	In School D Year 13 Chemistry (1) the students were given a diagram of organic compounds and the students had to complete the missing terms, eg, elimination, or the resulting compound after the process.
<b>Additional item of information:</b> explanation, reasons and examples of the key concepts.	In School C Year 12 English the task was to identify literary techniques used in the film Atonement; a student asked if physical conflict is a literary technique, and then asked for an explanation of physical conflict from the teacher.
	In School C Year 13 Media Studies the students were making a film, and searched the internet for films which they could use as examples of film techniques (eg, point of view, camera work).
<b>Preparatory or contextual information:</b> information that provides relevant background.	In School B Year 12 History class students were watching interviews (primary sources) in a documentary. The students asked when the documentary was made. The teacher asked, “Anyone got

	<b>Examples from the data</b>
	Google up?" A student found the documentary was made in 1989.
Key words or concepts: definitions, translations.	In School C Year 12 English class two students seek definitions: 1) S2 asks S1 for definition of repenting. 2) S5 googles for definition of cowardice, then thesaurus.
	In School D Year 13 English the teacher asks the students to look up a word and suggests the hardcopy dictionaries sitting to the side of the room. All the students use their devices.
Activities and procedures: information as to processes.	In School A Year 13 Accounting students were to complete financial statements.
Instructions for relevant activities.	In School C Year 13 Statistics students were asked to draft an outline of their assignment; they were to do it on A3 sheets of paper not on laptops. They were allowed to access the unit booklet.
Visual or object resources: relevant information is available but the resources are not the focus of attention.	In School B Year 12 History class students were studying the My Lai massacre and suggested wider reading was watching <i>Full Metal Jacket</i> for basic training, and <i>Band of Brothers</i> .

Table 5: Nuthall's coding of information items with examples from the data.

### 5.2.2.2 *Derived notes*

Derived notes is a form of disassembling the data that can be used instead of or with coding. Derived notes are notes about notes. They can include quotes, vignettes and the researcher's interpretation of data. They allow the researcher to think deeply about the data rather than struggle with the mechanics of the coding process (Yin, 2016, p. 200).

The use of derived notes arose through compiling and dissembling the data of each case into the activity theory triangle, which was done as each case was completed for the first pass of analysis. It was after the first two cases in the pilot study that the initial idea for the goals of learning action (Chapter 8) was identified. These are not at the level of sub-codes of the broad categories of the activity theory triangle and the information artefact, but are actions that engage all aspects of the activity theory triangle. The theory it draws from is Leontiev's hierarchical structure of human activity, and the dynamic relationship between the levels of activity, actions and operations, which is shown in Figure 8 in Section 3.2.3. Once the data was placed in the structure of Leontiev's hierarchy then it became possible to identify the conditions of the operations, the goals of the actions, and the motives of the activity. Reframing the data with theoretically significant terms is abductive reasoning. An example of using derived notes is shown in Table 6.

<b>Category</b>	<b>Operations</b>	<b>Actions</b>	<b>Activity</b>
1) Tool / technology artefact			
a) Hardware			
i) ...			
ii) Phone	Writing essay	Instrumental and cognitive	English
iii) ...			
b) Software			
i) School software	Learning management system, email, printing	Instrumental	Multiple
ii) Suite software	Writing essays, sharing documents	Instrumental and cognitive	Multiple
iii) Education specific software	Completing exercises	Instrumental and cognitive	Statistics and Chemistry
iv) The internet	Wider research	Cognitive and axiological	Multiple, but especially History and Media studies

*Table 6: An example of derived notes in table form.*

This table illustrates the *category* of the tool, with sub-categories of hardware and software, and there are further categories within those. Hardware includes phones, and software comprises school software, suite software, education specific software and the internet. These categories were drawn from the data. Focusing on the software, the operations that



were observed with each type of software is listed, the type of actions that are composed of the operations are identified, and the activity that was composed of the actions were identified. These are left broad in this example. Using derived notes identified that the same actions could be achieved through different tools, and this is elaborated in Chapter 8.

Education is an open and recursive system, and using derived notes enabled the researcher to retain a holistic view of the data. Yin (2016) notes the risks of using derived notes are inconsistency, inaccuracy, and reliance on select portions of the data while underusing or ignoring other portions of data. Inconsistency and inaccuracy were overcome through returning to the original data many times to ensure faithfulness to the data and accuracy of reporting. Certainly some data was used more than others in the initial analysis and interpretation, as some data illustrated or evoked concepts more than others. This was followed up by a review of the original data to ensure that none of the data was ignored or overlooked.

### 5.3 Considering the presentation of data

#### 5.3.1 Presenting multiple, similar cases

The research design was a multiple case study of 11 classrooms (Section 5.1.3), with the unit of analysis being the sociocultural activity of the students engaged in learning (Matusov, 2007) (Section 4.3). While the research was designed to account for between school differences as the participants came from urban and regional schools, and private, public and special character schools, it was also designed to capture between class differences, as classes from numeracy and literacy subjects were selected.

Across all of the classrooms the data collection drew from a variety of sources. For each case the data comprised at least:

- An interview with the teacher;

- Observations of the students, comprising a data record for classes over two (or four for the pilot study) weeks;
- The questionnaires of the students; and
- Data from the NZQA website about the standard the class is studying towards.

They could also include:

- Samples of the students' work (if available);
- Photographs of visual information in the classroom (if relevant); and
- Data available in the public domain about the community and the object of the activity.

As the data was collected for each class the data was reassembled as an activity theory triangle case. This highlighted the similarities and differences between the cases. There were differences between the cases: some classes were better at attending to learning tasks immediately than others, and some classes frequently sang. However, these differences were not related to the research questions: the use of the technology artefact, the instantiation of the information artefact, or the emergence of the information systems artefact. A difference that was related to the research questions was the difference in ownership of the devices, which in this thesis is identified as a component of BYOD. But BYOD was not a variable between the cases or even schools, it was a component of the rules of the school (Section 6.3.1). While it could be said that the BYOD schools were the private schools, the other schools were moving towards a BYOD model. Thus, this could not be considered a difference between the cases, but as a relationship between the nodes of the activity theory system.

Consideration of the cases with activity theory found that cases were not quite replicative, as there were variations, but also not contrastive. This raised the issue of how to present a multiple case study in this situation. Yin

(1981b, p. 62) identifies three approaches for presentation: case-survey, case comparison, and cross-presentation. Case-survey is appropriate for coding of single factor and cross-case tabulations, which is not this study. Case comparison is useful when the systems are open, semiotic and recursive, and where the cases are not replicative or contrasting, as they are here. Cross-presentation (Yin, 2016, p. 256) focuses on the concepts and themes presented over the cases, rather than a narrative of a single case.

Once the data collection was completed the data was reassembled a second time according to the nodes of the activity theory, and data from all the cases was included. This further showed that case comparison was a useful way to analyse the data, and cross-presentation which focuses on concepts and themes over the cases, rather than contrasts between them, is used to present the data in Chapter 6.

### 5.3.2 The complex unit of analysis

In Section 4.3 the unit of analysis was described as “the process of the sociocultural activity... the class of students as a whole engaged in learning.” However, as Yin (1981a, p. 103) found with education cases “the unit of analysis was complex and not easily distinguished from the context”. In Yin’s case the unit of analysis gradually shifted to the entire research project, whereas in this research, because the unit of analysis is dependent upon the sociocultural activity (Matusov, 2007) the unit of analysis is the activity of the students engaged in learning. The requirement of activity is constant, however the size of the unit of analysis ranged from the whole class to small groups to the individual within a single classroom for the duration of the purposeful activity. This still follows Vygotsky’s requirement, that the “... ‘unit’ designates a product of analysis that possesses all the basic characteristics of the whole. The unit is a vital and irreducible part of the whole”.

## 5.4 Conclusion

This chapter built upon the foundations of critical realism and activity theory. In this chapter the participants of the research who would populate the framework were identified, as was the process for making sense of the data. The resolution of the data into its component parts was described, and examples of the compiling and disassembling of the data were provided.

The next chapter presents the data.

## Chapter 6 Presentation of data

This chapter presents the data, and is key to a critical realist explanation, as “... a researcher must begin with the knowledge of a given phenomenon” (Williams & Wynn, 2018, p. 317), as this is the “... foundation for understanding what really happened” (Wynn & Williams, 2012, p. 796). Following the critical realist methodological model of explanation, this chapter presents the *resolution* of the complex event into its component parts, which is equivalent to the explication of events in the relationship among the methodological principles from Wynn and Williams (2012, p.797) (Section 3.1.2). This chapter identifies and abstracts the events that were experienced to provide a foundation for understanding what really happened.

This chapter will start by illustrating the richness of the phenomenon and the depth and breadth of the data with a vignette, before moving to the resolution of the phenomenon.

### 6.1 Setting the scene

It is a year 13 accounting class. The students are trickling in from recess in small groups, pairs and the occasional single, finding their way to their accustomed seats, groups dissolving and cohering fluidly with the ease of long familiarity. Bags are put aside, laptops opened, phones checked. On

time, the teacher strides in. Conversation peters out, and faces turn expectantly towards her.

The teacher tells the students to lower their laptop screens, and then talks to the whole class, setting out the expectations of learning for the lesson. The students need to create some financial statements. They reopen their laptops and access the documents that the teacher has already saved in their learning management system (LMS). They start to work on the problem. The students work individually or confer with their neighbours as to the best way to complete the task. The teacher moves around the classroom answering questions and assisting with the task, discussing depreciation with students.

A student says that he is having difficulty. The pre-inputted formula in the spreadsheet processes the data too fast for him to follow, and makes it difficult to return to his previous figures. The teacher goes to help him. Another student, discouraged, turns to Facebook on his phone. Within a minute he returns to task of his own volition, and asks his friends for help.

Within 10 minutes of the class starting four distinct actions involving the students and the information artefact were observed: (1) the students accessed information needed for the task, (2) the students undertook the task alone, with peers or with the teacher, (3) a student encountered a difficulty in completing the task, and (4) a student encountered a difficulty in completing a task and took a brief respite from it.

This was one of the first observations in the study, and over the course of the research the complexity and openness of the system became apparent. The cases are very different: there are eleven different classes and six different subjects. The students were doing very different things. In Media Studies students were preparing to create a documentary, while in History students were watching a documentary. In Statistics students researched house prices; in Chemistry students burnt methane. Within the cases the actions of the students were also very different. In the same period the students could be working as a whole class, in small groups or individually.

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In all classes students used technology, but not all the time, and not for the same purposes. In each class the students performed many different actions in their learning. The transitions between the changes were swift and smooth, with new forms and densities emerging all the time. Senior students are learning multiple items and processes in the same class at the same time. Nuthall has shown that even for students who are in the same class, and who are doing the same thing, their experiences are very different (2007).

### 6.1.1 Resolving the event into its component parts

The phenomenon will be resolved based on the categories imposed by activity theory, recognising that this in itself is a form of analysis in that it discriminates and classifies these concepts as “significant, noteworthy, relevant or otherwise important” (Bhaskar & Danermark, 2006, p. 286). This is vitiated at the next steps, abduction and retroduction, where theories about structures and relations are used to uncover the mechanisms of the phenomenon (Danermark et al., 2002, p. 123). The coding process was discussed in Section 5.2.2, and the deductive analysis in the chapter that follows used *a priori* codes that were drawn from theory, specifically activity theory, Lee et al’s (2015) analysis of the information artefact and technology artefact, and Nuthall’s (Nuthall, 2001b) items of information.

The data presentation is structured so a broad outline of technology in classrooms is presented before focusing in on specific aspects. It will start with the data illuminating the motivation of the entire activity, which is the *objective* of the activity. It will then present the cultural-historical context in which the students are working: what are the rules, the community and the division of labour features that their actions are embedded in. It will then focus on specific actions that the students undertook in their learning. For the actions the tools and the signs, the technology and the information, will be discussed.

## 6.2 The objective

In activity theory the objective is the actual result of the activity, as discussed in Section 3.2.4.1. The data was drawn from interviews with the teachers, observations, the student questionnaire and documents.

### 6.2.1 Passing the National Certificate of Educational Achievement standard

In the interviews the teachers were asked what the desired outcome of the activity was, eg, to acquire a new skill, complete a school task, identify information needs, or pass the subject. The teachers were unanimous that an objective of the activity was to pass the *standard*. The standard is the common vernacular for individual unit or achievement standards of the National Certificate of Educational Achievement (NCEA). These can be internal assessments which are marked by the teacher, or external assessments which are exams set and marked externally to the school and are taken at the end of the year. The standards that each class are working towards are described more fully in Appendix 3. Examples are:

1. The School A Year 13 Accounting class was working towards the external examination [NCEA Standard 91406](#): demonstrate understanding of company financial statement preparation. The final product to be assessed was an exam.
2. The School C Year 13 Media Studies class was working towards the internal assessment [NCEA Standard 91494](#): produce a design for a media product that meets the requirements of a brief. The final product to be assessed was in booklet form. This was also the basis for the following standard, which would produce a media product, which in this school was a short documentary film.



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One teacher said that passing the standard would give the students,

... the option to go to university, just to have the choice and not be forced into anything else. It is good to have options.

In every classroom passing the standard was the stated objective of the activity at least once. In every class there were forms of the statements by the teachers:

To get Excellence<sup>14</sup> you need to do  $x$

What are you aiming for [Excellence, Merit or Achieved]?

Forms of the question the students would ask are the obverse:

If I do  $y$  is that a Merit?

Do I need to do  $z$  to get an Achieved?

This objective, to pass the NCEA standard, was consistent across all of the schools. For both the students and the teachers this objective motivated their activity.

### 6.2.2 Other objectives

In the teacher interviews all the teachers expressed the hope that the students would enjoy learning and develop the disposition for life-long learning. One teacher emphasised the importance of students thinking, reflecting and being creative in their learning. In this teacher's class at the end of the period the students were asked:

What have you achieved?

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<sup>14</sup> A passing mark awards the student with a standard of Achieved, not passing is Not Achieved; achieved standards can be endorsed with Merit or Excellence.

This is subtly different from have you completed your work, and responses that included non-task related achievements, such as enjoying a poem, were acceptable.

All of the teachers had professional development on how to use the technology. One teacher commented that even though there was a lot of technology in the class, there was little direction on how to use it well. These objectives were articulated by the teachers, but not by the students.

The students were asked (Q13) if ‘In your opinion, does going online help you in your learning? Why?’ This was an open question to elicit broad responses as to the objectives of the students. However, as most of the responses appeared to be at the level of the object, eg, Yes because typing is a lot faster than writing and helps me to organise and edit my ideas more easily, this is presented in Section 6.6.

### 6.2.3 A limitation of the study

In the student questionnaire question 7 was intended to relate to the objectives of the students’ learning activity; it was designed drawing on Biggs’ work on motives and strategies of learning and studying (1987) and is shown as Figure 16. Methodologically the question is flawed as in Biggs’ research motivation is an individual psychological construct, whereas in activity theory it is a collective, social construct. The answers identified that students had multiple psychological motives, but they do not relate to motives and the process of the sociocultural activity, or the construction of social practices.

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7. Did the application help you to achieve your objectives? Some possible objectives are (tick as many as are relevant):

- To do enough to answer the teacher's questions
- To do well and gain personal satisfaction with my work
- To do as well or better than my classmates
- To have a solid education to get a well-paid or secure job
- To learn, as there is enjoyment in learning
- To be at the top of the class
- Other...

*Figure 16: Student questionnaire, question 7, Did the application help you to achieve your objectives?*

The study had to rely on data from the observations, teachers' interviews and documentation to establish the social, collective motivation of the activity.

## 6.3 The rules

Rules are the norms and sanctions that specify and regulate the expected correct procedures and acceptable interactions among the participants (Cole & Engeström, 1993), as discussed in Section 3.2.4.2. The data is drawn from the interviews with the teachers, the questionnaire, documents in the classroom, and the schools' websites. There are rules about the requirements to have a computer, using the technology in the classroom, and around using applications on the internet.

### 6.3.1 Rules about BYOD

The schools' websites set out the rules for the devices in the classroom. In the Private schools (Schools A and C) it was compulsory to bring a device,

and one of the schools required that the device was a laptop not a tablet. In Schools A and C 100% of the students had smartphones and their own devices.

The State (School B) / State-integrated (School D) schools did not at the time of the study require students to BYOD. They were phasing in the requirement that all students have a device, but it was not yet compulsory for the classes that were observed. The data drawn from question 3 of the questionnaire shows that in School D, with 35 participants, 2 students owned laptops and 2 students owned tablets, ie, almost every student used a school provided device. In School B, with 63 participants, 19 students owned laptops and one owned a tablet. The number of students in non-BYOD schools using their own and school devices is shown in Figure 17.

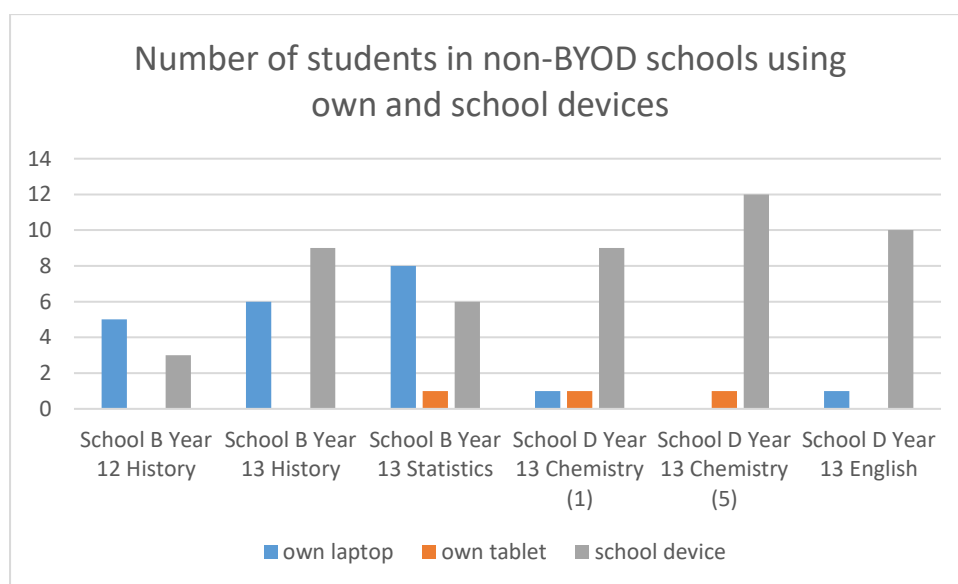


Figure 17: Number of students in non-BYOD schools using own and school devices.

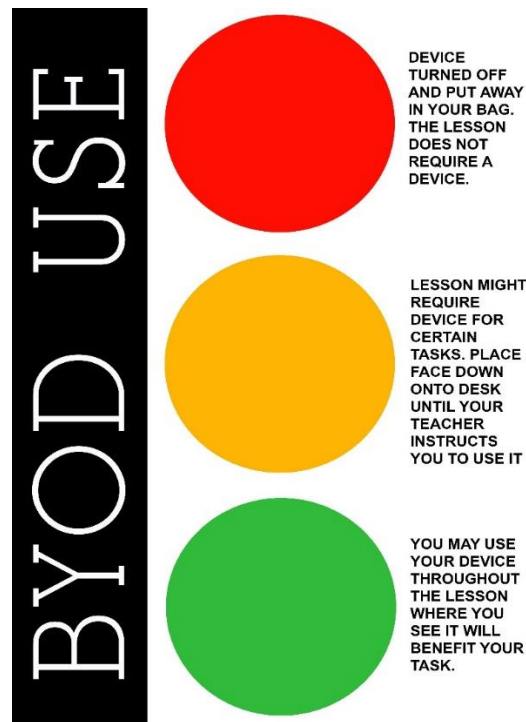
### 6.3.2 Rules in the classroom

The data on rules in the classroom were drawn mainly from the teacher interviews, and confirmed by documentation in the classrooms and observation of behaviour. The Private schools (Schools A and C) had clear rules about using technology in the classroom. School C had implemented a school wide rule in the year prior to the study that during class phones

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needed to be placed face down, which the teacher strictly enforced. The rule was relaxed in the school the year of the study, and the teacher did not enforce the rule strictly in the senior years. In the interview the teacher said that the students appeared to consider whether their phone use was appropriate for tasks in the classroom. It was in this school that a student was observed using a phone to write an essay, which was acceptable to the teacher.

School A allowed teachers to create rules for their own classrooms, and both the teachers had made it clear that technology was only to be used when they allowed it. They were clear in their instructions, being explicit when the students had to put screens down and when they could use their laptops. One of the teachers had a traffic light sign to reinforce the message of when technology could be used; a generic sign is shown as Figure 18. In these classes students were generally on task. Students were observed off task (eg, looking at social media) only when they had already completed the task, or required assistance and were waiting to see the teacher to discuss their work, or if they had tried and failed to complete the task. In all cases the students quickly returned to task.



*Figure 18: A poster using a traffic light to illustrate rules around BYOD use.*

The non-BYOD schools did not have ‘hard and fast’ rules about when to use the technology in the classroom, relying on the students knowing classroom conventions. The teachers expected students at this level to self-manage or learn how to self-manage, and allowed and expected students to be off task during class. Students were expected to work well, but take a break when they needed to. That being said, one teacher was strict with a particular student, who tended to write or key in their work with one hand while playing games on the phone with the other.

### 6.3.3 Blocked websites

In the student questionnaire, question 9 was intended to identify if there were any rules which required the student to use particular websites, and specifically asked if websites were blocked, Figure 19.

- 
9. Was there any problem accessing the applications? Eg were some blocked, was there technical difficulty in accessing the applications, was the screen too small, or did the device have inadequate software?

*Figure 19: Student questionnaire, question 9, Was there any problem accessing the applications?*

In Schools A and B access to Facebook was blocked. In School C classes were encouraged to develop Facebook pages, and students were observed both on Facebook and on Facebook messenger. Students in School B also noted that some other websites were blocked, but the websites were not named, and it is unknown if they were blocked by the school or by the Network for Learning, which manages and filters access to the internet which is provided to the schools.

Three schools use [Hapara](#) or [Linewize](#), which are New Zealand products which enable teachers to monitor students work and internet access. In an interview a teacher noted the power of the platform, when she recounted that once, when she was at home sick, during the scheduled lesson she accessed her students' browser activity through Hapara and closed down a student's off task applications. Another teacher closed down a student's YouTube during an observation. In another school students were able to go on YouTube to access music to listen to during class.

## 6.4 Community

The community is the collective aspect of the activity and can be elaborated at different levels: it may be the immediate group, the wider organizational community or society at large. Data was drawn from observations and documents, being the schools' websites and other education websites.

### 6.4.1 The classes

It was observed that the students are sociable in the classes. These are senior classes in secondary school and it is possible that some of the

students have been together for five years. The average size of the class was 17, and the median was 15, so the classes are small and the students know everyone in their class. It was observed that students are also together in drama productions, kapa haka, and sporting teams. The students know each other well.

All of the classes have online spaces. The researcher observed one school uses Microsoft. The other schools use Google products, and one school uses Google classroom. The Google schools are monitored with Hapara. In an interview a teacher said that because all of the required texts are available on the Google classroom, and she posts the slides from the class there, the students have no excuse if they are absent or lose concentration during the class.

The students at the Private schools (Schools A and C) also have community spaces online for the students that are not monitored. These were used for school work and for social reasons. For example, in School C Year 12 English two students were on the class Facebook messenger page.  $S_1$  was across the aisle from  $S_2$ .  $S_2$  turned around and gave earbuds to  $S_1$ . The students were within arm's length. They had not talked to each other but had messaged each other on Facebook. The School A Year 13 Accounting class had an online subject page; while the front pages were used for work there was also a social page which the students used to promote community by posting holiday photos.

#### 6.4.2 The schools

All of the schools have a learning management system, which is chosen and administered by the school. All of the students need to log on to see their timetables and notices, and save and print their work.

The schools are able to be defined as Private and State / State-integrated schools. Private schools draw their students from middle to high income families, and are not restricted to enrolling students in a particular geographic zone. The State-integrated school is defined as a school 'of a



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special character', such as a school affiliated to a religion, and is not restricted to enrolling students in a particular zone (Ministry of Education, 2018a). The State school must enrol students who live within the local geographic zone. The State and State-integrated schools are considered to be in middle to high income areas.

The schools can also be characterised as urban (Schools A, C and D) and regional (School B). This variable identified a difference between the schools because students in urban schools have access to school buses and the city bus system. In the regional school there is only one school bus to school which arrives just as school starts, and one school bus from school which leaves immediately after school finishes. This particularly disadvantaged a student in School B Year 13 Statistics for whom the school bus was the only transport from and to home. This participant, who did not have a laptop or tablet, was not able to borrow one from the school, as the librarian said all devices were lent out well before the beginning of school and the bus did not arrive in time. In every class the students were required to work online, to access NZGrapher and write up their assignments. In the statistics classroom there were desktops, but not all classrooms at the school had desktops available. In the statistics class the student used a desktop for every lesson. It was known that this student did not have internet access at home either. Statistics was a flipped classroom: the student was not able to watch the videos as homework, nor stay late and work in the library, because there was only one bus to get home which left promptly at the end of the school day.

### 6.4.3 Collective learning

Question 8 of the student questionnaire, shown in Figure 20, was intended to uncover the collective aspects of learning. It was related to whether the student worked individually, collectively with the teacher or collectively with another student. Even though the question asks for information related to only one website most of the responses included multiple answers. For example, in School C Year 12 English 21 students participated, 17

completed the questionnaire, 13 answered this question, and there were a total of 21 different answers. The most any student ticked was three options. For these cases the data were inconclusive as it was impossible to link the websites with collective or individual learning. This was repeated in all the classes except the two listed below.

8. Generally, for the most used application or website in this class, did you use it because:

a.	You thought of using it	<input type="checkbox"/>
b.	The teacher required you to use it	<input type="checkbox"/>
c.	The teacher suggested you use it	<input type="checkbox"/>
d.	Another student suggested using it or was using it	<input type="checkbox"/>
e.	Another reason, eg, another person or website directed you to it (please specify)	

Figure 20: Student questionnaire, question 8, Did you use the application working individually or collectively?

The two partial exceptions to this were School B Year 13 History (14 completed the questionnaire, 13 answered this question, 22 responses) and School D Year 13 Chemistry (1) (10 completed the questionnaire, 10 answered this question, 13 responses). The lessons to which the questionnaire relates were not in the usual classrooms: the history class was in the library doing project work, and the chemistry class was in the computer lab completing exercises on a chemistry website developed for New Zealand secondary school students, BestChoice for Chemistry. The entire chemistry class was only on one website in this class; the history class only had one task during the class. A comparison of the results for these classes is shown in Figure 21.

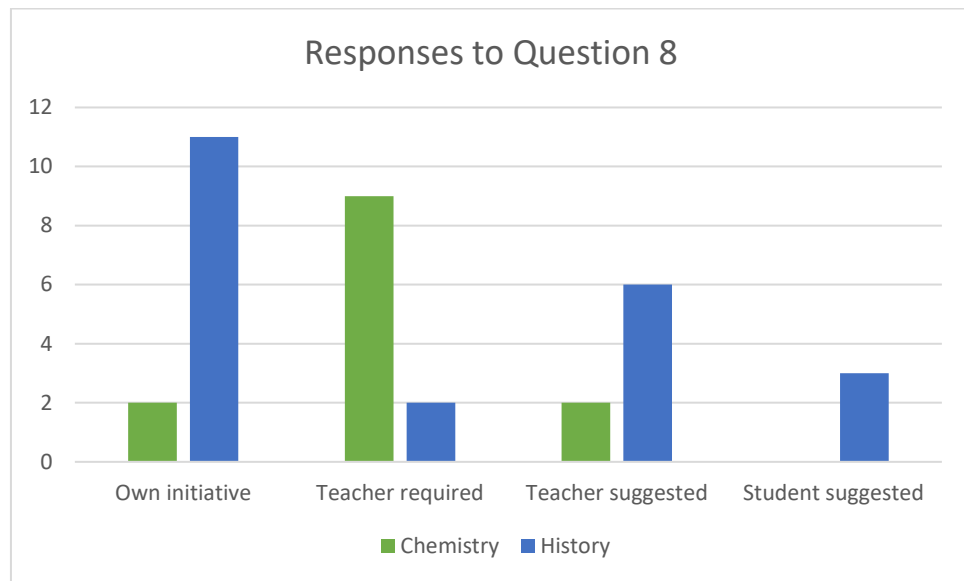


Figure 21: Chemistry and history classes' responses to Question 8.

This data shows that when the student is required to complete an exercise which is set by the teacher and which is on a particular website, as in Chemistry, then the students are required by the teacher to use that website. In this class the website that the students visited on their own initiative may have been YouTube, as it was in this lesson that the teacher closed down a student's device for being on YouTube, but the question was not specific enough to determine this.

In the History class the students were conducting their own project, and were required to perform their own research: they were expected to use their own initiative to seek out information online, but they also sought assistance from the teacher and other students.

## 6.5 Division of labour

### 6.5.1 The seating arrangements

The vertical dimensions of the division of labour and the relationship between students and teachers can be illustrated in the seating arrangements. In particular the seating arrangements illustrate the placement of the technology: where the fixed desktops are placed, and how

the seating arrangements work with portable technology. This data is drawn from the observations in the classrooms. Of the eight teachers seven of them taught in their own classrooms which they could set up. The laboratory of the chemistry teacher was being renovated during the study and the classes were moved for every lesson, so will be excluded. School B Year 13 History was conducted in the library for the duration of the study, specifically for the resources that it afforded, and will be included. The computer lab used by School D Year 13 Chemistry (1) was also used specifically for the resources that it afforded, and will also be included.

In all classrooms the front of the room was the wall that had the whiteboard on it. The teacher's desk was at the front and to the side of the rooms. In the figures that follow the key is shown in Figure 22.

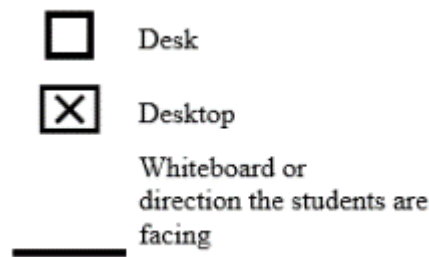
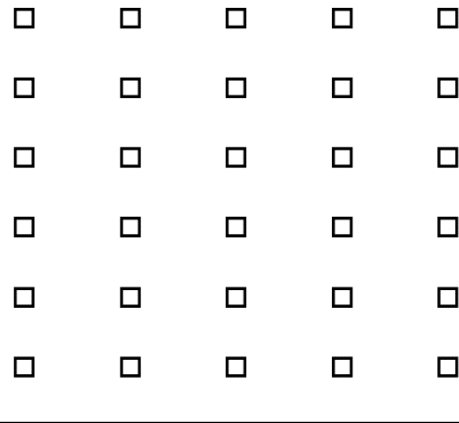


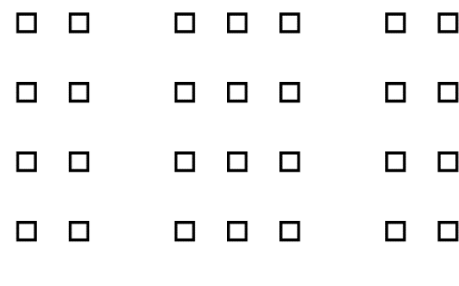
Figure 22: Key to the seating arrangements.

The seating arrangement of individual desks facing the teacher, sometimes described as *traditional* and illustrated in Figure 23, was not found in any classroom.



*Figure 23: Figure of traditional seating arrangement.*

The most common seating arrangement was the paired, which was used in four classes: School B Year 13 Statistics, School C Year 12 English, School C Year 13 Media Studies, and School C Year 13 Statistics. While the term is *paired* the most common configuration was two-three-two, although none of the classrooms were particular in the precision of the rows. This configuration is shown in Figure 24. Here the seats face the teacher, but allow discussion between the students. In the first three classrooms there was a modified paired seating arrangement as there was a bank of desktops against the back wall.



*Figure 24: Figure of paired seating arrangement.*

School B Year 12 History had a group pod seating arrangement, shown in Figure 25. Here the students face into the group, but are able to see the teacher.

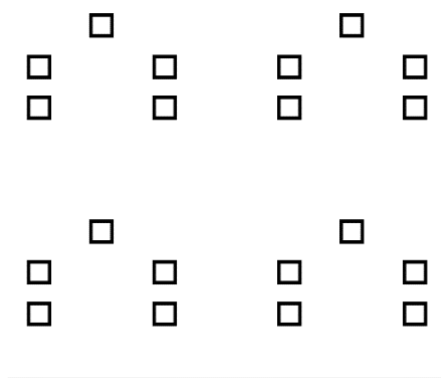


Figure 25: Figure of group seating arrangement.

School A Year 13 History had a roundtable setup, modified with pairs on each side, shown in Figure 26. This was the second largest class with 24 students. Here the students face into the group but are able to see the teacher.

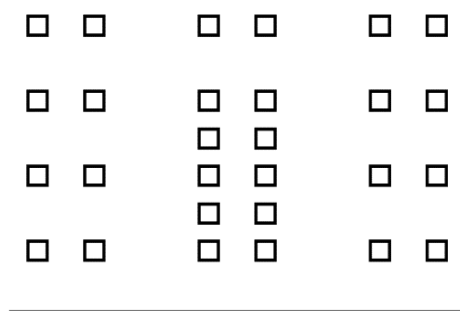
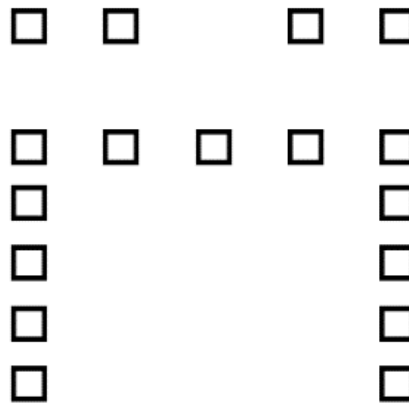


Figure 26: Figure of roundtable with pairs.

Classes with a horseshoe seating arrangement were School A Year 13 Accounting and School D Year 13 English, as shown in Figure 27. The accounting class could not all fit around a single horseshoe and there were pair pods along the back row. The students face each other and can see the teacher.



*Figure 27: Figure of horseshoe seating arrangement with pairs.*

The library where School B Year 13 History was studying had two sections: the first was with the books and the second was with the desktop computers. In the book section the students sat at round tables with their books and laptops, able to see and talk to each other.

In the computer part of the library and the computer lab the computers were on long tables. The computer lab was in a horseshoe arrangement. In the School B library, and at the back of School B Year 13 Statistics, School C Year 12 English, and School C Year 13 Media Studies the desktops were against the wall, as shown in Figure 28. The technical requirements of cabling electricity and ethernet, and health and safety requirements tend to place the hardware against the walls. The material requirements of the space of a screen, box and keyboard mean that the space between students is greater when the students use a desktop than when they use a laptop or paper. In these classrooms the majority of the class are on laptops in paired pods facing the teacher; the students on the desktops sit apart from each other and face away from the teacher and other students. In School C the desktops are used rarely: the students all have laptops and only use the desktops when their laptops are not working properly. In School B Year 13 Statistics only 60% of the students have their own devices, and this is the

best resourced class that was observed in this school. The desktops are used by the same students every lesson.

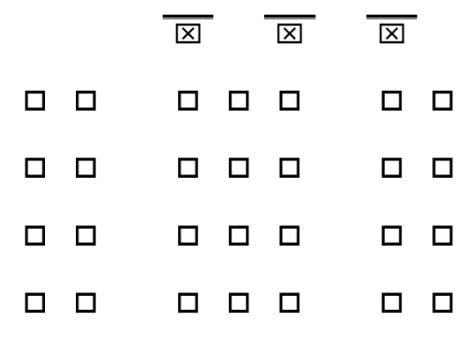


Figure 28: Figure of paired seating with a bank of laptops against the back wall.

### 6.5.2 The structure of lessons

The structure of the lessons illustrates the vertical dimensions of the division of labour. This data is drawn from the observations in the classrooms. The seating arrangement of Figure 23 is associated with the teacher lecturing the students, described as a *traditional* structure. This was not observed in any of the classes. In two classes students worked on their own projects for the duration of the observation, School B Year 13 History and School C Year 13 Media Studies. This involved the students setting their own objectives and completing them. The students would work individually, while the teacher would check the progress of each student. One class, School B Year 13 Statistics, was effectively a *flipped classroom*, where the “chalk and talk” was on the internet, which the students would watch in their own time, and they would complete the exercises during class. In this class the students emailed the teacher if they required assistance, and they would be put on the list of students called up to discuss their work with the teacher. The teacher conducted one group session with students who were moving on to the next subject. In these classes the students worked individually, or with the teacher. All other classes were a mix of teaching to the whole class or groups, and the students completing exercises as groups or individuals.



## 6.6 The object

In activity theory the object is the goal of the action; it is the problem space that the activity is seeking to resolve. This section presents the data on the relationship between the tools and the object, through asking ‘what are the students using the technology for?’ The data is mainly drawn from the questionnaire, with additional data from the observations.

In the research design the object was mapped to question number 4 of the questionnaire, which asks, ‘In this class that has just finished what did you go online to do?’; Question 4 is shown in Figure 29.

---

In this class that has just finished what did you go online to do? You may tick more than one box

- |    |  |                          |
|----|--|--------------------------|
| a. | To take notes  | <input type="checkbox"/> |
| b. | To read information that my teacher has collected  | <input type="checkbox"/> |
| c. | To develop a plan for written work   | <input type="checkbox"/> |
| d. | To write up my work  | <input type="checkbox"/> |
| e. | To manage my school work through the school learning management system                           | <input type="checkbox"/> |
| f. | To manage my school work through other applications, eg, Dropbox, OneNote or email               | <input type="checkbox"/> |
| g. | To access social networks, eg, Facebook or Twitter   | <input type="checkbox"/> |
| h. | To access a web browser, eg, IE or Firefox   | <input type="checkbox"/> |
| i. | To access a translation application, eg, through Baidu   | <input type="checkbox"/> |
| j. | To find information by searching for it, eg, Google, Google Scholar, Wolfram Alpha               | <input type="checkbox"/> |
| k. | To find information through an online encyclopedia, eg, Wikipedia                                | <input type="checkbox"/> |
| l. | To find information in a specialist website, eg, National Library, ERIC, YouTube                 | <input type="checkbox"/> |
| m. | To use a specialist application, eg, a specialist maths site                                     | <input type="checkbox"/> |
| n. | To complete work in another subject  | <input type="checkbox"/> |
| o. | To complete work in this subject, but for an advanced assessment not covered in this class today | <input type="checkbox"/> |
| p. | Other (please specify)   |                          |

Figure 29: Student questionnaire, question 4, What did you go online to do?

Of the 145 students who answered the questionnaire all of them went online for at least one goal, except for the three students who did not have hardware to access the internet, see Section 6.7.1.1. Students did at least one of these actions, and many indicated that they did more than one action. An example of a student's answer from the online questionnaire is included in Figure 30.

4. What did you go online to do? You may tick more than one box.

- To take notes
- To read information that my teacher has collected
- To develop a plan for written work
- To write up my work
- To manage my school work through the school learning management system
- To manage my school work through other applications, eg, Dropbox, OneNote or email
- To access social networks, eg, Facebook or Twitter
- To access a web browser, eg, IE or Firefox
- To access a translation application, eg, through Baidu
- To find information by searching for it, eg, Google, Google Scholar, Wolfram Alpha
- To find information through an online encyclopedia, eg, Wikipedia
- To find information in a specialist website, eg, National Library, ERIC, YouTube
- To use a specialist application, eg, a specialist maths site
- To complete work in another subject
- To complete work in this subject, but for an advanced assessment not covered in this class today
- Other: \_\_\_\_\_

Figure 30: An example of a student's answer to question 4 showing multiple responses.

The answers to question 4 are shown as the stacked chart in Figure 31. This figure shows that online activities of (a)<sup>15</sup> note-taking, (b) reading teacher prepared information, (d) writing up work, (h) going online and (j) conducting a search are highly popular. The first three activities are conducted in classrooms around the world, while (h) going online and (j) conducting a search are only done in classrooms that have technology. The activities of (a) note-taking, (b) reading, and (d) writing in the technology

<sup>15</sup> This numbering is taken from the paper questionnaire. The online questionnaire lacked the functionality of numbering the questions.

rich classrooms of this study are being done online. These are not being done on specialist websites but on general websites.

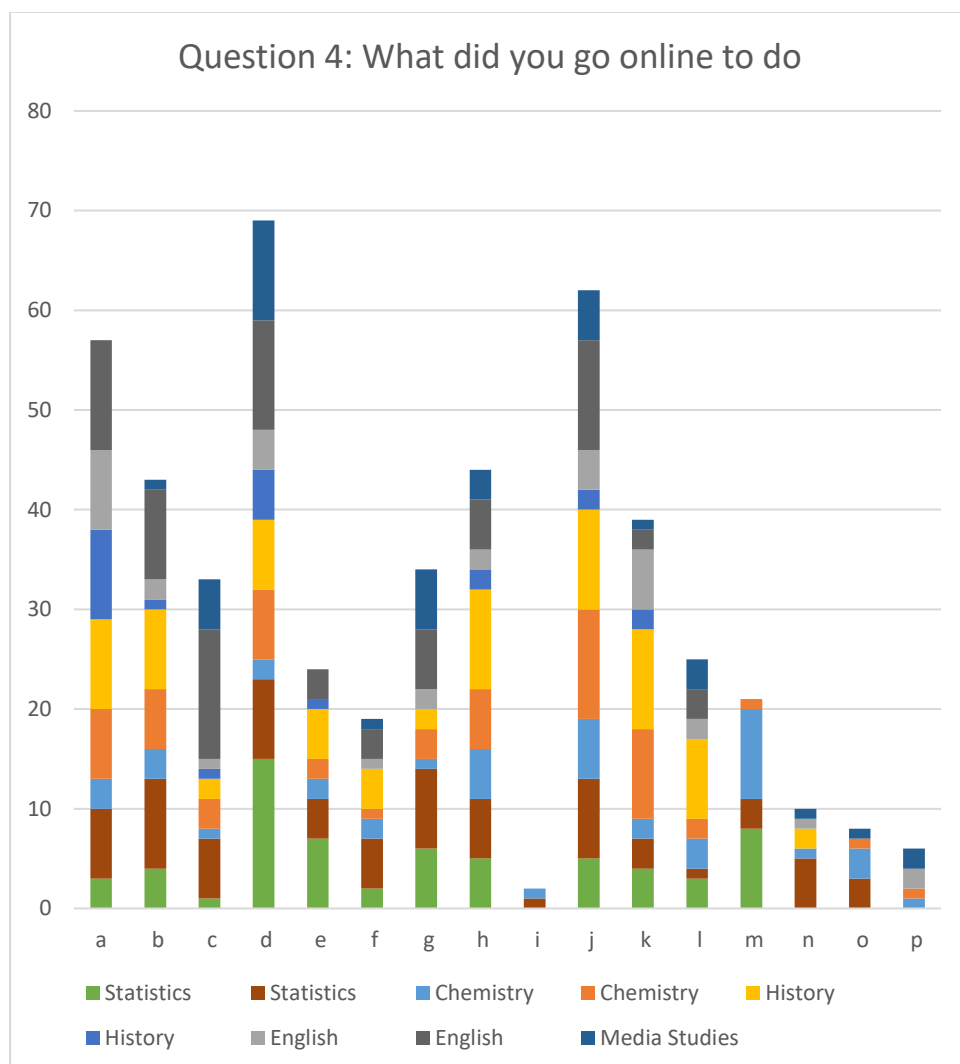


Figure 31: Stacked chart showing answers for Question 4: What did you go online to do?

The online information sources are (b) teacher prepared information, (j) information found through search, (k) information found on an online encyclopaedia, and (l) and information found on a specialist website.

All the classes were conducting research at some point, identified through the high scores for (j) finding information through the search engines. However, where the engines directed them is dependent upon the subject. Students in history went to encyclopaedias such as Wikipedia, and specialist sites like the National Library and the Stockholm International

Peace Research Institute. Students in Media Studies went to YouTube and Vimeo.

It can be seen that in the response for (m) to use a specialist application, the breakdown of the classes is quite different from the others. Statistics and chemistry were the only subjects which had specialist websites for New Zealand secondary schools, and they had to be used in these classes. For statistics the assessment required the students to graph statistics, which could only be completed on the specialist websites; in chemistry the students were completing exercises on the website. The history classes also accessed specialist history websites in the classrooms, but they were not built specifically for the secondary school curriculum, and it was not compulsory to use them.

Question 12 further explored these answers by asking if the student preferred ‘to perform this action electronically or on paper?’ The options being take notes, read information that my teacher has collected, develop my plan for written work, and write up my work. The results were similar across schools and the answers are aggregated in Figure 32.

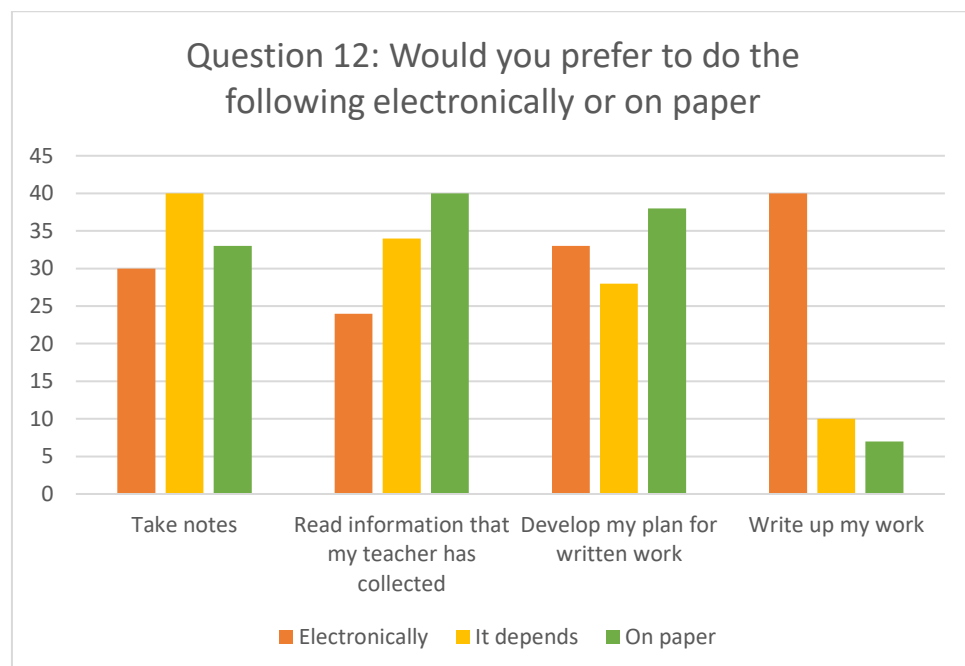


Figure 32: Response to Question 12, Would you prefer to do the following electronically or on paper?

There is a clear preference for writing up work electronically. For the actions of taking notes, reading information that the teacher has collected, and developing a plan for written work there is a preference for working with paper over working electronically. However, the ambivalent answer, it depends, is also prominent.

In the observations this was reflected in an exercise in School C Year 12 English. They were to list motifs in the text individually in note form, and then discuss their findings with the class. Approximately half the students worked on devices, and half on paper, and there appeared to be little difference to the work that they did. It was noticed that when it came to the group discussion the students who worked on paper contributed more to the discussion, but there is insufficient data to investigate this further.

The students were asked (Q13) if ‘In your opinion, does going online help you in your learning? Why?’ A broad selection of positive responses are listed below:

- Yes
- It is good to have all the information needed and my own files in one place
- Because I don't have to fossick through my bag
- Yes, because it helps me further understand information especially when I don't understand the work done in class
- Yes because it gives us a new form of learning
- Yes, as it allows me to clarify any confusion
- Yes, online learning is visually more appealing as there can be videos and tutorials
- Easier to write up, faster, taking less books around as only have to carry laptop

- 
- Access to more information, an easy way to keep all my notes in one place, means work can be done in a pair and both people have access to the notes
  - Yes, because you can search up things very easily and quickly, which is convenient
  - Yes because typing is a lot faster than writing and helps me to organise and edit my ideas more easily. I can also use Google to discover new ideas to enhance my learning
  - Yes, because we have access to the internet (which provides us with basically everything)

However, other comments were more nuanced:

- I'm answering yes for this question because it does help my learning significantly. The access to information is better than ever before and I definitely learn more online and browsing information this way than reading it out of a book or having to look it up manually. I do however find that when reading information that I should be taking in I prefer to do that on paper form because I take it in better than reading it online, I also prefer to take notes on paper. I think that you can get very distracted online because there are so many social networks available at your fingertips. However I think that going online and doing the majority of work online does save a lot of paper - something that is an added positive to working online
- Sometimes, for languages it helps to hear the words but in bio and stats I prefer to use paper and pen
- It can give background information but book work is better
- I find financial statements are harder to complete online

And then there were the three dissenters:

- Nah, not really mate. Easy to get distracted with other websites
- I would much rather use books than computers
- I hate computers

## 6.7 The tool – the technology artefact

In activity theory the students' use of tools mediates their activity. As discussed in Section 3.2.2.3, the activity is mediated by both tools and signs. For this thesis Vygotsky's tool is equated to Lee et al's (2015) technology artefact. This section will identify and discuss the hardware, software and broadband that the students experience in the classroom.

### 6.7.1 Hardware

This section identifies the hardware that the students had access to in the classroom. The data was drawn from interviews with the IT departments and staff of the schools, the observations of the students, the student questionnaires, interviews, and documentation freely available on the internet. In this research the technology is *within* the learning environment, it is not *the* learning environment. For example, in a history class the students had access to multiple hardware and software as well as access to a textbook, the teacher, and other students.

#### *6.7.1.1 What hardware do the students use?*

In this study a device that can access the internet is a desktop, laptop, tablet, or smart phone. The responses to Question 1 of the questionnaire, 'In this class that has just finished did you have a device that can access the internet?', showed that of the 145 participating students who completed the questionnaire three did not have access to a device that could access the internet. These students were in one class (Year 12 history) in one school (School B), in a class of 15 students. This school had laptops that the



students could borrow from the library, but as stated earlier they were always borrowed well before the first period. This classroom, unlike two other rooms which were observed at this school, did not have desktops. Two of these students indicated in the questionnaire that in a perfect world they would use a laptop and a tablet to access the internet; one did not choose a medium. Conversely, in 10 of the 11 cases every student had access to at least one device that could access the internet in the classroom.

In School A all the students had a laptop and a phone (except 1 student who had a tablet and a phone, but would have preferred a laptop. It was suggested that this student's laptop was being repaired). In School C all of the students had a laptop or tablet and a phone. These are the Private schools, and it is compulsory for students to bring their own device.

The non-BYOD schools (B and D) recommended students bring devices. In these schools if the students did not have their own laptop they could borrow laptops or tablets from the school. In the questionnaire the students were asked (Q3), 'In this class, which device(s) did you actually use to access the internet? Please tick all devices that you used'. The response from the non-BYOD schools is shown in Figure 33.

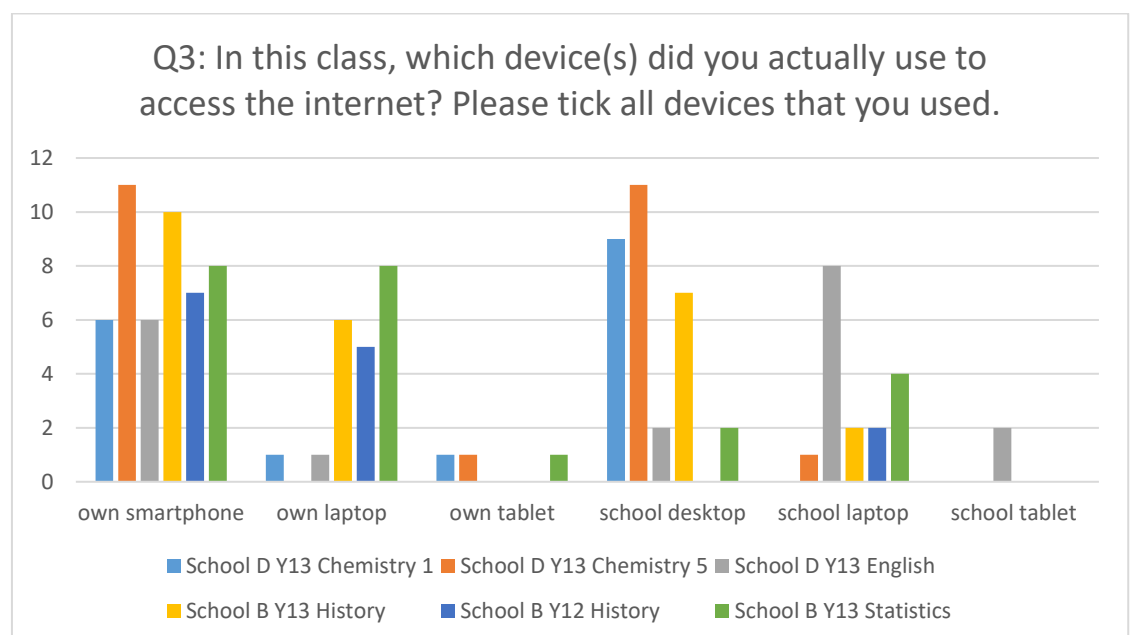


Figure 33: Response to Q3 - devices actually used to access the internet.

The high use of school desktops in three classes (School D Year 13 Chemistry (1), School D Year 13 Chemistry (5), School B Year 13 History) are accounted for as Chemistry (1) went to a computer lab for part of the class, the Chemistry (5) went to the library specifically to access the desktops, and the History class was in the library to access the desktops and other resources (including books and a photocopier).

In the classes that were not in a computer lab there was at least one student who *was* using a school provided laptop; in School D Year 13 English only one student *was not* using a school provided device. In this school 19 out of 35 students were using school supplied devices. In School B 17 out of 63 students were using school supplied devices. Desktops were available in two of the three school spaces that were observed, and the desktops were used, on average over the period of the study, by three students in the Year 13 Statistics classroom and seven students in the Year 13 History library. The same students were observed regularly on the desktops. As noted above, not all schools had sufficient laptops to provide for all students who wanted one.

The students were asked (Question 2) ‘In a perfect world which device(s) would you use to access the internet?’ Students frequently ticked multiple boxes indicating they would like a smartphone, a desktop, a laptop *and* a tablet. Six percent would even use Microsoft HoloLens in a perfect world. In all cases the students preferred a laptop (90-100%) to a smartphone (40-92.3%), and a smartphone to a tablet (0-27.3%). While in some classes a tablet was not selected at all as a preferred device, in all classes a desktop was a preferred device by at least some students (7.7-60%). The students were not interested in Google glasses (2015 questionnaire) or smartwatches (2017). There is a fairly close correlation between what was desired and the actual technology that was available to the students, see Figure 34.

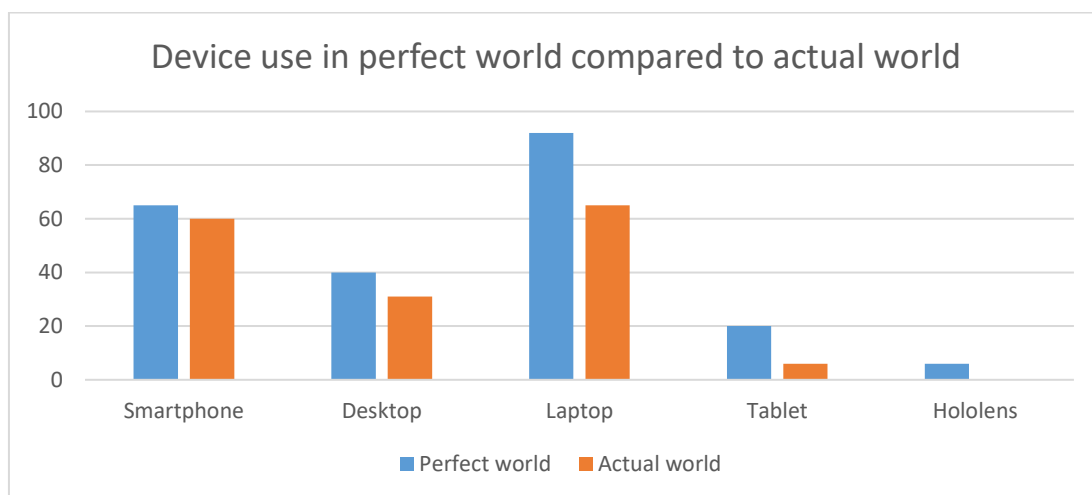


Figure 34: Responses in percentages to Question 2 In a perfect world which device would you use? and Question 3, Which device did you actually use?

There is at least one instance where there was not a close correlation between what was desired and the actual technology available. Desktops are preferred by the students over tablets, yet as discussed in section 6.3.1 the schools are all at, or moving towards, BYOD policies.

In the student questionnaire, question 9 was intended to identify if there were any technical difficulties with the technology. The questionnaire did not distinguish between the hardware, the software and the broadband. Question 9 is shown in Figure 19 in Section 6.3.3. In all cases more students reported no problem, or did not answer, than identified problems. A student in School B who was working on a smartphone wrote, “small screen but otherwise good”. Students in the BYOD schools (A and C) sometimes had issues with their devices:

My laptop keeps shutting down randomly (it's an old laptop) so that restricts what I'm able to accomplish in a lesson.

My laptop that I normally use won't connect to the internet.

My device ran out of storage space to download an excel file so I could not use iNZight. Instead I used the desktop in the room.

In Schools A and D sets of laptops or tablets were able to be booked by a teacher for a class. In School D a set of iPads were booked by a teacher for work in the classroom, although the teacher thought that she had booked the laptops. The students sent the iPads back to the library to be see if the set of laptops could be issued, but they were being used by another class. The students chose not to use the iPads.

In one class phones were used by the whole class for learning. School D Year 13 Chemistry (5) had to review their knowledge of the subject before learning new material. The teacher's intention was to identify the students' current knowledge, and give the students an opportunity to consolidate and refresh previous knowledge and correct any errors. The class was divided into groups; each group was given an area of learning to research and present to the class. A student asked the teacher if they could use a Kahoot!<sup>16</sup> quiz. The teacher assented, and all the student groups created a Kahoot! quiz. The students used desktops to research and write their presentation on Google Slides, and a projector to present their slides. The teacher clarified and amplified information during these sessions. The students then consolidated their knowledge using a Kahoot! quiz. The students create a quiz that other students have to answer within a set amount of time. The quiz creator shows the quiz questions on the laptop which is projected onto the whiteboard. The students log onto the quiz on their phones to answer. On the whiteboard they can see who was right and who was the fastest. From the energy and laughter of the students it appeared that they enjoyed this activity. The teacher often paused the quizzes to amplify and clarify the students' learning in the whole class.

Phones were used by individuals in all classes. The data showed a few students using them for school related purposes. In one class (School C

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<sup>16</sup> [Kahoot!](#) is a free game-based learning platform for “teachers of awesome, classroom superheroes and all learners.”

Year 12 English) a student was observed using a phone to write an essay. The teacher also noticed and engaged the student in conversation.

T: You used to write in a book.

S: I write it on the phone and copy it into the book so I can change things.

T: Is it time consuming?

S: I work on the phone not the tablet because it has YouTube.

T: Isn't the screen small?

S: I just prefer it.

In this school and School B students were observed listening to music on YouTube, with the permission of the teachers.

In one class only (School B Year 13 History) two students reported in the questionnaires that they used phones to read. They conducted a Google search, read a Wikipedia article and information on a specialist website. While the English student was happy with the screen size one of the history students found it “small, but otherwise good”. In School B Year 12 History two students used phones to take notes, write up work and conduct searches. One of the students noted that in order to achieve desired outcomes the student should “remember to bring a laptop to next class”.

In one class (School C Year 13 Statistics) it was noticed that a student had taped over the webcam on the laptop.

Other technology in the classrooms were that every teacher had a laptop, and in some classes the teacher's desk had a desktop. These were able to be linked to projectors which were used in nine classes. In one class a student used the teacher's desktop when their laptop ran out of memory. No teachers were observed using phones during class.

### *6.7.1.2 When do students use the hardware?*

The devices are always there and they are always on. In the two BYOD schools it was observed that the first thing the students did on entering the classroom was put their devices on the desk, open them up and turn them on. This was also the case in the classroom that was based on a flipped classroom in the non-BYOD school, School C Year 13 Statistics. The students on the desktops went straight to the desktops and logged in. The devices were available to the students until the end of the class when they put them back in their bags. The access to the devices was only limited briefly at times when the teacher wanted to talk to the students, at which time they asked the students to close their screens.

In the non-BYOD schools the students would greet each other and chat as they entered the classrooms, and only bring out their devices as they were needed. In School D Year 13 English the students were watching a film that was projected onto the whiteboard and discussing it as a whole class, and the students' devices were accessed when they had individual exercises. In comparison, in School B Year 13 English class, a BYOD school, the students were discussing a film that had already been seen, and devices were taken out at the beginning of the class. In both these class, for some tasks, some students chose to use paper in preference to the devices.

### *6.7.1.3 Where did the students use the hardware?*

During the observations four classes moved location, and each move was motivated to access a different technology. In School A Year 13 History the students went to a lecture theatre to watch a visual resource (part of an episode of a documentary) because it was a large class and the students were better able to see the documentary in the physical structure of the lecture theatre than in the classroom. Many students opened their laptops in the lecture theatre. In School B Year 13 History the students moved to the library to access desktops and books. In School D Year 13 Chemistry 1 and 5 the students moved to the library and computer lab to access desktops. In

these situations some students still chose to use their laptops even though they had one-to-one access to desktops.

#### 6.7.1.4 How many hardware devices were accessed?

The students frequently used multiple devices. To illustrate the multiplicity of combinations, of the ten students who completed the questionnaire in School D Year 13 Chemistry (1) four students used only a desktop, and 4 used desktops and phones in the same class. One student used a phone, the school desktop, and their own laptop, another used a phone, the school desktop and their own tablet. This is a non-BYOD school that went to a computer lab during the class. This is represented in Table 7.

<b>Combinations of devices used in answer to Q3, a non-BYOD school.</b>	
<b>Combination of devices used</b>	<b>Number of students using combination</b>
School desktop only	4
Smartphone and school desktop	4
Smartphone, school desktop and own laptop	1
Smartphone, school desktop and own tablet	1

*Table 7: Combinations of devices used in a classroom*

#### 6.7.2 Software

This section identifies the software that the students had access to in the classroom. A broad definition of software is taken. As this research focuses on internet access, for the purposes of this research the software includes browsers and the applications that students access through the browsers, such as Google search, GoogleDocs, and Wikipedia, as well applications that are supported through their own platforms, such as Spotify. Services, such as OneDrive, are included in software. The data was drawn from the observations, the student questionnaires and interviews.

### *6.7.2.1 What software do the students use?*

Section 6.7.1.1 identified that only three students in School B Year 12 History did not have hardware that could access the internet. Section 6.6 showed that only these three students did not access the internet during the lesson, meaning that the other 142 students who answered the questionnaire accessed the internet.

The students often had multiple windows open and switched between them frequently. In the schools that allowed Facebook often messenger was open at the bottom of their screens. The students used multiple applications at the same time. For example, in School A Year 13 History a student had all the following applications open at the same time and was moving between them:

- a. the school learning management system, looking at the documents posted by the teacher;
- b. a word processing programme, writing the essay;
- c. a browser, accessing an external history website; and
- d. a browser, accessing an email to contact the teacher.

A limitation of the research design is that with observation it is difficult to identify which software a student is using at any particular time. The hope for triangulation through computer logs was not fulfilled, as discussed in the Section 4.5.5. For some observations identifying the software was easy, for example, when the teacher directed them to Bestchoice for Chemistry or NZGrapher for Statistics. It was made more complicated when a statistics teacher gave the option to use NZGrapher or iNZight. The teacher discussed the benefits of using each of the websites with the whole class. Some students were indecisive over which to use, and some students were ready and willing to proselytise for their favourite websites.



The software the students accessed can be divided into four categories:

- a. school software;
- b. suite software;
- c. education specific software; and
- d. the internet.

### *6.7.2.2 School software*

School software is essentially the software the student has to interface with the school. This is the learning management software, the school email system, the printing system. All the students interact with the school software.

### *6.7.2.3 Suite software*

Suite software are the packages developed by the big providers. In this study Microsoft and Google were used. The Microsoft suite includes the applications Outlook, Word, Excel, OneNote, and the services OneDrive; all of these were observed being used in the classroom. The G Suite includes Docs, Forms, Gmail and Drive; all of these were observed being used in the classroom. This software was ubiquitous and prevalent throughout the observations.

### *6.7.2.4 Education specific software*

Education specific software is software developed by educators for New Zealand secondary schools. These can be further divided into specialist and generalist websites. Specialist websites are created for specific NCEA standards. In the classrooms only three examples of this type of software were observed. In Statistics students used [NZGrapher](#), developed by Jake Wills, a maths teacher in New Zealand specifically for supporting the teaching of the NCEA Statistics Standards. Universities have created the other two websites: [iNZight](#) for graphing statistics and [Bestchoice for](#)

Chemistry. These were used by the whole class for specific exercises. The teacher directed the students to the websites. The students would not have been able to complete their tasks without accessing the software.

There are a few other websites available that have been developed for the New Zealand secondary student, but these are general purpose. Studyit, is a 'one stop site for achieving in NCEA maths, science, and English'. The TKI and NZQA websites were also mentioned in classes as resources, but the first is produced for teachers, and the second gives information on the assessment standards.

#### *6.7.2.5 The internet*

The internet broadly covers all the websites that the students visited. This was the least accessed software. There were only two occurrences where the students were free to conduct their own research in the internet, and they were in the two project based assessments. 'Project based' is a technical term meaning that the students choose a project and learning is built around it. Both of these projects were in Year 13 classes.

In the School C Media studies class the students were studying towards the NCEA Standard 91494: Produce a design for a media product that meets the requirements of a brief. This is an internal assessment worth 4 credits. In this class the students could choose any subject for their brief. Some subjects being studied by the students were ethical fashion, faith, and loyalty to Wellington. The students needed to access the internet to gain an achieved with excellent endorsement. This project was the basis for this assessment and the one that was to follow, where the students produced the media product, which was a short documentary.

In Media studies the students used well branded websites, including YouTube, Vimeo and BuzzFeed, which were easily observed. They also used other websites which the researcher was not familiar with and could not identify during the observations. The students interacted with many different websites in a single class.

In School B Year 13 History class the students were studying towards the NCEA Standard 91437: analyse different perspectives of a contested event of significance to New Zealanders. This is an internal assessment worth 5 credits. In this class the students could choose any event from a topic entitled 'the US century'. Some events being studied by the students were the dropping of the atomic bomb on Hiroshima, the torture and prisoner abuse in Abu Ghraib, and the War in Afghanistan. The key learning of the students was to learn how to evaluate and compare historical documents. The students needed to access the internet to gain an achieved with excellent endorsement. In this class it was more difficult to identify the websites the students accessed. There were a few well branded websites such as CNN and Stockholm International Peace Research Institute that could be observed and identified. The range of projects was so broad that the students were generally working on completely different things, and visited pages so briefly that it was difficult to identify them before the student had moved on to the next page.

It should be noted here that School A Year 13 History class was also working towards this standard. In that class the event was the chosen by the teacher, the New Zealand Northern Wars, and the assessment was not project based. Most of the material was collated by the teacher and was put on the learning management system, or the teacher indicated where the material could be found on the internet. The students could gain an excellent endorsement with the material provided by the teacher. One student used material found on the internet in their essay from Wikipedia.

In the non-project based classes the students had limited reasons to use the internet. In the statistics classes the students were able to select data from the internet. The teachers suggested data that was easily findable and limited, included nutritional information about MacDonald's products, local house prices, and times for paint to dry. The purpose in these classes is not how to research data, but how to convert the data into graphs and interpret the graphs.

### 6.7.3 Broadband

This section identifies the broadband that was accessed by the schools. The data was drawn from interviews with the IT departments and staff of the schools, and documentation freely available on the internet.

#### 6.7.3.1 *Fibre v cable*

In this study only School D benefited from the Government investment in the UFB. The schools and their access to fast broadband is presented in Table 8, which shows that while all schools had access to fast broadband only School D's broadband was provided by Chorus under the UFB. School A had fibre installed by a private company which specialised in installing fibre for schools some time before the UFB investment. School B had fibre installed by a private company which was established in the area of school B, also before the UFB investment. School C was in an area which did not have fibre at the time of the study, and achieved fast broadband on VDLS cable provided by a provider other than Chorus. School D had fibre provided through UFB. State and State-integrated schools do not pay for the fibre into the school to their server under the UFB (Ministry of Education, 2011a).

<b>School</b>	<b>Characteristics</b>	<b>Fast broadband</b>
<b>A</b>	Urban, Private	Fibre
<b>B</b>	Regional, State	Fibre
<b>C</b>	Urban, Private	VDLS Cable
<b>D</b>	Urban, State-integrated	UFB - Chorus

*Table 8: The schools and their access to fast broadband through the UFB and other providers.*

#### 6.7.3.2 *Technology required to access the fibre and cable*

In the State and State-integrated schools staff on the technology team said that the school technology had been upgraded through SNUP (School Network Upgrade Project) and WSNUP (Wireless SNUP), which is the

subsidised upgrade of electrical cabling and switches. While this is subsidised by the Government the schools pay approximately \$200 per student for State-integrated and \$150 per student for State schools (Ministry of Education, 2011a). WSNUP does not include wireless access points (WAPs) and Voice over Internet Protocols (VOIP) if the school wants to use the internet for telephone services (Ministry of Education, 2016a). After the schools were WSNUPped they still experienced lack of coverage in the classrooms, and both schools paid for significant extension or replacement of the subsidised wireless system. The cost of digital technology is listed as a reason for rising costs in schools (Tomorrow's Schools Independent Taskforce, 2018, p. 107). The Private schools are not eligible for a SNUP subsidy and pay for their own cabling, switching and WAPs.

All the students in all the classes had access to wireless fast broadband. Generally access was fast and seamless. The students were directly asked in the questionnaire whether they had problems accessing their applications, and the issue of access to the network was implicit in the question. Q9 asked, 'Was there any problem accessing the applications? Eg were some blocked, was there technical difficulty in accessing the applications, was the screen too small, or did the device have inadequate software?'

Only School D had no complaint about the wifi, whereas the other schools all had a few complaints, although in total there were only eight complaints out of 145 students who completed the questionnaire:

The wifi was a bit slow and did not load information fast enough.

Sometimes the wifi cuts out at this end of the school - it means that everything stops and we can no longer edit or keep writing as the application uses wifi to be able to save changes.

Sometimes the wifi cut off and I could not access my work.

The wifi was a bit slow.

In School D there was praise:

No, I get good internet.

## 6.8 The sign – the information artefact

In activity theory the students' use of tools mediates their activity, and tools includes both tools and signs. For this thesis Vygotsky's sign is equated to Lee et al's (2015) information artefact. The information artefact is categorised according to Nuthall's categories of information items. Information imbued every aspect of the study; as Biesta (2015b) notes, the classroom is semiotic because it relies on communication, interpretation, and making meaning of information. This section will present examples that will focus on examples where the information artefact was used in conjunction with the technology artefact. This is the basis of later analysis, where the information systems artefact emerges from the interaction between the social artefact, the technology artefact and the information artefact.

### 6.8.1 Explicit item of information

Explicit concept information is the full information needed to understand a specific proposition, concept, explanation of procedure. These knowledge items are not synonymous with the curriculum learning, but are parts of it. A specific proposition may be a fact, a name or a description.

In School A Year 13 History the students were given accounts from both Māori and pākehā<sup>17</sup> of the battle of Ruapekapeka in the Northern War. Māori accounts relied on oral history, and were presented in a documentary which the students watched in a lecture theatre. The pākehā accounts were

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<sup>17</sup> Pākehā are non- Māori New Zealanders, and in the context of the Northern War include British Europeans.

presented in newspaper articles and letters, which were sourced by the teacher and available to the students through the class online space.

### 6.8.2 Implicit or partial item of information

Implicit or partial information contains some but not all of the key elements.

In School D Year 13 Chemistry (1) the students were given a diagram on a whiteboard of organic compounds and their associated processes, and the students had to write in the missing terms, eg, elimination, or the resulting compound after the process.

### 6.8.3 Additional item of information

Additional items of information include explanations, reasons and examples of the key concepts.

In School C Year 13 Media Studies the students were making a film, and searched the internet for films which they could use as examples of film techniques (eg, point of view, camera work).

### 6.8.4 Preparatory or contextual information

Preparatory or contextual information can include background information, revision of previously presented information, and related discussion.

In School B Year 12 History class students were watching interviews (primary sources) in a documentary. The students asked when the documentary was made. The teacher asked, “Anyone got Google up?” A student found the documentary was made in 1989.

In School D Year 13 Chemistry (5) the students used Kahoot! to quiz their classmates using smartphones about previously presented information.

### 6.8.5 Key words or concepts

Key words includes definitions and translations, but do not contain knowledge items.

In School C Year 12 English class two students seek definitions on their own initiative to understand their task:

S2 asks S1 for definition of repenting.

S5 googles for definition of cowardice, then looks up online thesaurus.

In School D Year 13 English the teacher asked the students to look up a word and suggests the hard copy dictionaries that were stacked to the side of the room. All the students used their devices.

### 6.8.6 Activities and procedures

Activities and procedures produce, create and lead directly to concept-relevant information. They are more than reading and writing, and include carrying out a science experiment or making a model.

In School A Year 13 Accounting students were to complete financial statements in Excel.

In School C Year 13 Media Studies the students created surveys to test the viability of their project.

### 6.8.7 Instructions for relevant activities

These are the instructions for the activities such as described in Section 6.8.6.

In School C Year 13 Statistics students were given an activity to draft an outline of their assignment: they were to do it on A3 sheets of paper not on laptops. They were allowed to access the unit booklet.



### 6.8.8 Visual or object resources

Visual or object resources provide relevant information but are not the focus of attention.

In School B Year 12 History class students were studying the My Lai massacre and suggested wider reading was watching *Full Metal Jacket* for basic training, and *Band of Brothers*.

## 6.9 Conclusion

This section has presented the data through resolving it into significant terms derived from activity theory, Lee et al's (2015) analysis of the information artefact and technology artefact, and Nuthall's (Nuthall, 2001b) items of information. The presentation moved from a broad outline to focussing in on specific learning events. It started with the data illuminating the motivation of the entire activity, and identified the objective of the activity. It then presented the cultural-historical context in which the students are working: what are the rules, the community and the division of labour features that their actions are embedded in. Using the data presented here the next sections use abduction and retroduction to identify possible antecedent causes.



## Chapter 7 Activity theory analysis

The previous chapter *resolved* the complex event into its component parts, using activity theory, Lee et al's (2015) analysis of the information artefact and technology artefact, and Nuthall's (2001b) items of information, culminating in the presentation of the data in Chapter 6. The next step in Wynn and Williams figure is the explication of structure and context (Section 3.1.2). This is equivalent to *redescription* in the RRRE model, that is, to use theory to understand the relationships and context of the components.

This chapter will redescribe the data presented in Chapter 6 using multiple frameworks to give new meaning to a known phenomenon. Chapter 7 uses the framework of activity theory to interpret the data that has already been resolved in Chapter 6, and this chapter will conclude with the initial findings of the research, which represent an understanding of the data. It will also identify some threads that run through the research, that are the traces of the social and philosophical explanations of the generative mechanisms which underlie the phenomenon. Chapter 8 will use the framework of Leontiev's dynamic hierarchy of activity. Retroduction will be used in **Error! Reference source not found.** to identify the mechanisms that underlie the use of technology in the classroom.

This chapter will use the framework of activity theory to redescribe the data presented in Chapter 6. Contrary to Chapter 6 this chapter will start with the individual nodes and then layer upon them the relationships between the nodes and place the data in its cultural historical context. This is a method in activity theory to ascend from the abstract to the concrete, in that any empirical data is an abstraction from reality, and placing the data in its network of relationships, social context and causal powers makes our understanding of the data more concrete.

### 7.1 Activity theory

This section seeks to find out how the activity theory conceptualisation of the tool can help to interpret the data. In activity theory the tool is physical and psychological, the tool and the sign, or in information systems terms the technology artefact and the information artefact. The use of the tool or the sign does not merely improve or extend the existing operation, it allows us to control our behaviour through communication, planning, structuring and regulating, that is, through mediating and organising our activity. The technology artefact is externally oriented, and changes our physical world; the information artefact is internally oriented, and changes ourselves. The physical tool changes our behaviour of learning; the sign changes our knowledge.

The task of the researcher is to uncover the relationship between the behaviour and the tools and signs, as the tool *may* play an *auxiliary* role in the psychological activity of learning. In the learning activity the first stimulus is the function of the task: the student is stimulated to write, read, answer a question. The second stimulus is the tool or sign, which may help to organise the activity of learning, to become a new, complex, mediated act.

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## 7.2 The technology artefact

The technology artefact is the emergent totality of the hardware, software and broadband, and its causal properties are not reducible to the properties of its component parts, see further about emergence in Section 9.3.1.

However, the components are related to rules, the community and the division of labour, which affect what components are available to become part of the technology artefact. The next sections discuss the hardware, software and broadband, and their relationships to the rules, the community and the division of labour. The data was drawn from interviews with the IT departments and staff of the schools, the observations of the students, the student questionnaires, and documentation freely available on the internet, and the analysis of the nodes that were discussed in Chapter 6 based on the data.

### 7.2.1 The hardware

This study found that only three students did not have a device to access the internet; in this study 98% of the students had access to devices. The most prevalent device used by the students was the phone, and then laptops, both school and student owned. The data showed that the students preferred laptops (77.8-100%) to tablets (0-27.3%) by a wide margin. It is possible to explain this high percentage of students who have access to a device as a straightforward matter of choice: the student chooses to use a laptop therefore laptops are used in the classroom. However, to do so would be an epistemic fallacy, a failure to consider the deeper causal structures of the phenomenon, particularly as many students knew and stated that the devices could at times hinder their work.

#### *7.2.1.1 The hardware and the rules and the community*

The devices are embedded into the classroom experience of the students, and the devices are spatially and temporally ubiquitous. Almost every student has access to devices in all their classrooms and at all times.

Activity theory suggests two possible explanations for this ubiquity. The first is a result of the relationship between the nodes *tool* and *rules*. The most prevalent hardware is laptops (Section 6.7.1), which are required in Schools A and C, and encouraged in Schools B and D, under the BYOD policies (Section 6.3.1). The BYOD policies are moving the students towards laptops and tablets, even though students prefer desktops over tablets. The BYOD rules are pushing certain types of hardware into the classroom.

The second is a result of the relationship between the nodes *tool* and *community*. The students have to use the school software (Section 6.7.2.2), which includes the learning management systems, and the suite software (Section 6.7.2.3) implemented by the schools. These are cloud based software, and the students require hardware to access them. These choices are not driven by the students; these are choices made by the school administration, and their pedagogical, financial and technological reasons for doing so are unknown. It is beyond the scope of this thesis to further examine the structure of the cloud services or to examine the choices made by the schools.

The BYOD rules also impacted on the use of the technology in the classroom. In the non-BYOD schools the students did not reach for their devices immediately upon entering the classroom, as the students did in the BYOD schools. One non-BYOD class the students did not open technology until directed by a teacher; in another class three students did not use technology at all. There was a noticeable difference in BYOD and non-BYOD classrooms.

This section shows that almost every student in the cases had a device that could access the internet during the classes. This section showed that not only the type of hardware used, but also the fact that it is used, is contingent on the rules and the community of the school. The next sections show that there are differences in the experience of the students with different types of

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hardware. The attitudes to laptops and tablets were different, as were the attitudes to phones.

### *7.2.1.2 The hardware and the community*

When asked what devices they would like in a perfect world the students frequently ticked multiple boxes indicating they would like a smartphone, a desktop, a laptop *and* a tablet. However, there was one student who had a phone but not a device, who was not in a position to borrow a school laptop, and not all classrooms in the school had desktops (Section 6.4.2). This particular situation was only discovered through discussion with the teachers. It is not known if there were other students with the same conditions. In this single known case the geographic location in which the community is set affected the access of the student to the hardware. The issue of internet access at home is beyond the scope of this thesis, however, it is estimated that in New Zealand as at September 2018 there are 100,000 students in 40,000 households who currently have no internet access at home (Ministry of Education, 2018b). The Ministry's statement does not identify the factors that result in a lack of access, but the initiatives to ensure equitable digital access are being implemented in schools in low income, non-urban areas. In this study there is a single identified student, and there is insufficient evidence to draw conclusions or generalisations.

On the other hand, in comparison to the wider society, the schools in this study are in middle to high income areas. Two of these schools are Private schools. Private schools in New Zealand can require students to purchase expensive devices; one Private school (not in this study) requires design students to purchase a MacBook Pro, which costs from [NZ\\$2,199.00](#) to [NZ\\$4,699.00](#)<sup>18</sup>. The other two schools in this study are moving to requiring devices.

Compare this to a school in a less affluent area, which, on its website, advises that Chromebooks are suitable for senior students provided that

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<sup>18</sup> As on 4 June 2018.

they are taking subjects that do not require specialist software.

Chromebooks are available from [NZ\\$249.00](#)<sup>19</sup>. Schools in the least affluent areas do not have device requirements on their websites.

It must be emphasised that even though the schools in this study were Private or above decile 8, there was a class (that was not in a computer lab) where every student required the school to provide devices. It is not known if the students could not afford to purchase devices. It is also not known if students have not taken subjects because they cannot afford the hardware, and this research did not observe any design subjects or subjects that required specialist software. New Zealand is broadly homogenous, and it is known that there are students who are disadvantaged at schools in middle to high income areas (Tomorrow's Schools Independent Taskforce, 2018, p. 110). There is a divide between those who can afford the hardware, and those who cannot, even within the affluent schools that are the subject of this study.

With BYOD the students are responsible for purchasing, insuring, maintaining and upgrading the hardware and software. The data shows that even students in the Private schools did not always have top of the range hardware. The reported problems with their devices (“it’s an old laptop”, “won’t connect”, “ran out of storage”; Section 6.7.1.1) show that students may not have the ability to afford new laptops, nor the ability to ensure that the devices are in good working order. These Private schools have IT departments that are able to assist these students. The other schools do not have IT departments, yet they are moving to the BYOD model.

Equitable access to technology is an important consideration, and researchers, practitioners and policy makers need to be aware of it in any implementation of technology in the classroom, especially as this section shows that the community also tends to move students towards the technology through BYOD policies.

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<sup>19</sup> As on 4 June 2018.



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### *7.2.1.3 Hardware and the division of labour*

The division of labour has two dimensions. The vertical dimension shows the relative power and status of individuals; the horizontal dimension measures the division of tasks within an activity, such as collaboration and sharing.

The seating arrangement is one aspect of the classroom which can reveal power arrangements. Research suggests that traditional, rowed seating indicates a high power difference between the teacher and student, and a pedagogy with low social construction of knowledge. None of the classrooms in this study used this arrangement. Horseshoe arrangements are intended to encourage co-construction of knowledge between the teacher and student, while roundtables and pods encourage co-construction of knowledge between the students (Rands & Gansemer-Topf, 2017), indicating lower power structures.

The seating arrangement can also reveal aspects of the horizontal division of labour. This is the division of tasks within the activity in activity theory, and Lee et al (2015) note that the instantiation of the division of labour can be a social artefact in its own right.

The placement of fixed desktops and portable devices is considered within this theoretical background, and it is here that the relationship between the division of labour and the hardware comes salient. The students who had paper and laptops were able to move into pods (group or pair), but the students who were on the desktops were in fixed seating arrangements. Moreover, the physical structures of the table, wiring and peripherals required that each student on a desktop was at a physical distance from the next student, further individualising them. The students on the desktops also faced away from the teacher and the rest of the class.

Material aspects of the technology on the plane of the horizontal division of labour removed the student from the collective activity of learning, and collective actions of learning. If the pedagogy is focused on learning

together, ie, the social construction of knowledge and *ako*, then this in itself is concerning. However, issues of equity also arise. The schools with a bank of desktops against the wall were School B (non-BYOD) and School C (BYOD). In School C all the students had their own devices, and the desktops were only used when there was a problem with the laptops, such as low battery or memory. In School B the same students were using the desktops at each lesson. It has already been established that one of the students did not have a laptop, and could not borrow a laptop from the library because of travel constraints from being in a regional school. This student is now further removed from the collective learning activity through the material constraints of the technology.

The structure of lessons reveal the division of tasks within an activity, a horizontal dimension of the division of labour. Most of the classes had a range of actions, and multiple methods of achieving them, and often worked in pairs and groups. In classes where the students were completing projects or it was a flipped classroom the students' actions tended to be individual and they spent a lot of the class on the technology.

It can perhaps be said that there was only one class where the technology drove the classroom experience, and that was School B Year 13 Statistics, a class which used a system very similar to a flipped classroom. A flipped classroom is based on the premise that the students listen to lectures on podcasts at home and practice their exercises in the classroom where the teacher is available to help them in their learning. As it was a statistics class the students were required to use graphing software to complete their work. The students worked individually and sought help from the teacher rather than from the other students. This was also the classroom with the student who had no laptop nor access to the internet at home, which raises the equity of access to technology.

#### *7.2.1.4 Phones in the classroom*

Almost 100% of the students in this study had phones. In New Zealand laptops are encouraged to be used for learning in classrooms; phones are

not. Laptops and tablets are legitimated and sanctioned by government policy, school administrations and parents, phones are brought into the school by the students. When asked ‘In a perfect world which device(s) would you use to access the internet?’ some students would use a smartphone (0-27.3%). In all classes at least half the students reported that they used the phones to access the internet during class. Data has been presented showing that students use their phones for schoolwork. The English essay writing student was using Google Docs on a smartphone, and two history students used a phone to conduct a Google search, read a Wikipedia article, and read information on a specialist website. While the English student was happy with the screen size one of the history students found it “small, but otherwise good”.

Some students also reported that they went on the internet to access social media accounts and to contact friends for non-class related reasons. The questionnaire was not structured to inquire whether the non-class activities were conducted on phones or other devices.

Generally teachers allowed the students to have their phones to hand, and rules about phones were discussed in Section 6.3.2. While the observations showed that students did work on phones, it appears to be generally assumed that a student on a phone is not working, and in one case a teacher confiscated a phone which the student could get back at next lunchtime. The student protested not because the student was doing work on it but because the student wanted to contact people.

Of course laptops and desktops are also able to be used for distraction: one student was observed catching up on Coronation Street on a laptop for the entirety of a class; another student watched basketball on a desktop after completing the set work; and many students had Facebook messenger open (although School C has class Facebook pages).

This finding shows that the hardware used by student is affected by the rules and conventions of society, the school, the teacher and the classroom, as well as personal preference.

### 7.2.1.5 *The role of different types of hardware - what is a desktop?*

The students generally have access to their own laptops and phones, as well as school laptops, tablets and desktops. The students do not distinguish between the devices: they use whichever device is available and appropriate for their task. In one class a student's laptop's memory was full and the student worked on the teacher's desktop; in this particular case the student started an activity on one device and finished it on another. The questionnaire asked if the students used a desktop, laptop, tablet, phone or Google glasses (2015) / Smartwatch (2017) / Microsoft HoloLens (2017). One of the students asked another what a desktop was. None of the students expressed an interest in using Google glasses or Smartwatches in their learning, and only six were interested in a VR head set. The latter options were included as introductory rapport building questions (Peterson, 2000), and while the lack of interest in future technology is interesting it is worthwhile to note that the technology of the future in 2015 was no longer in existence in 2017. However, there is insufficient data to comment on the transience of technological fads in educational settings.

This data can be interpreted as the students are able to use a variety of devices but that they are not particularly interested *in* the devices. What the devices *do* seems to be more important than what they *are*. It appears that the principle of telonomic push, that activity is derived from what is implicit in the form of the device, is more important than the teleological pull. The next section will examine what the technology actually does.

### 7.2.1.6 *The function of the hardware*

What hardware does is execute software. Apart from this very specific function, the hardware is manufactured to be used in a broad range of contexts. This has, for this research, two consequences. First, the hardware was not developed for educational purposes. The Google executive in charge of Chromebooks said that the swift rise of Chromebooks in the classroom (in June 2016 there were 60 million students using Google Apps for Education) took them by surprise (Jesdanun, 2017; Singer & Isaac,

2016). Secondly, the hardware can perform multiple functions, it is a general tool. For example, the laptop is a significant collection of tools. There is a keyboard to input data, a screen for output, and a processing unit. Some laptops have tools that can do other things, for example cameras and speakers. That the hardware used in the classrooms is a general tool not made specifically for education is relevant when the form and matter of the tool will be discussed in Chapter 9.

### *7.2.1.7 Conclusion*

This section shows that there are multiple tensions in the activity theory triangle across the relationships between the nodes. The rules and the community tend to push technology into the classroom, yet there are rules which limit when the students can and cannot use it. The division of labour shows that, depending on the technology, there can be a push away from social construction of knowledge to individual learning on that technology.

That students work over a range of devices and can shift between and substitute laptops and desktops, indicates that it is not the hardware *per se* which is driving the activity, but what the devices can do. As a dominant function of the hardware is to execute software, the next section considers the software that is executed on the hardware.

## 7.2.2 Software

This section considers the software that the students had access to in the classroom. A broad definition of software is taken, and includes systems software, applications software, services and webpages.

New Zealand students are in technology rich environments (Cuban, Kirkpatrick, & Peck, 2001). On the multiple devices available to the students there are multiple software options for multiple purposes. The students often had multiple windows or apps open and switched between them frequently. When the students were given simple options between websites, eg the choice between using NZGrapher or iNZight in the

statistics classes, some students were indecisive over which to use, and were persuaded by students who were ready and willing to proselytise for their preferred websites. This observation reinforces the understanding of senior secondary students as able to make informed choices about their use of technology in the classroom.

#### *7.2.2.1 The software and the hardware*

The software is ubiquitous in the classrooms. This interpretation is a necessary corollary to the interpretation that the hardware is ubiquitous. Hardware has no purpose without software: all the hardware has associated systems software, and the students use that to access application software.

#### *7.2.2.2 The software and rules*

In Schools A and B access to Facebook was blocked; Facebook is often considered deleterious to learning and is blocked in schools (Belo et al., 2010). On the contrary, in School C classes were encouraged to develop Facebook pages, and students were observed both on Facebook and on Facebook messenger during the classes. Students in School B also noted that some other websites were blocked, but there is no information on what those websites were, nor whether they were blocked by the school or by the Network for Learning.

This indicates that schools are still learning about and experimenting with technology in the classroom. Belo et al (2011) reported that Facebook was blocked because the administrators thought that the students are easily distracted and that blocking it would return them to task. On the other hand, some schools are experimenting with social media.

#### *7.2.2.3 The software is conflating with the sign*

The software and hardware are being treated separately for analytical purposes, however they are entangled and inseparable. Increasingly so is the software (a technology artefact) and the content (an information artefact). This is illustrated by Google which is a search engine and an

information provider, although it does not always provide the source(s) of the information. For example, students in School C Year 13 Statistics were required to find information on nutrition in MacDonald's products, and Google provided the result shown in Figure 35. Students were observed using the data from the information box on the right of the screen. The sources are described as *including* USDA. It does not detail which parts of the information were sourced from the USDA, nor provide full reference details. There is no way to identify the other sources. The students are assuming the integrity of the search algorithm.

The issue of information literacy then becomes relevant. It is easy to find information on the internet, but not all of it is useful, or even correct. In this study there are two examples of the incorrect use of internet found information. In history one student accessed information about the historical context of the event from Wikipedia, but it was for the wrong time period. Another student was accessing university / industry level information in chemistry, which may have been too specific for the school assessment, see Section 7.4.

**McDonald's Hamburger**

Nutrition Facts		McDonald's Hamburger	
Amount Per 100 grams		Calories 264	
		% Daily Value*	
Total Fat	10 g	Saturated fat	3.5 g
		Monounsaturated fat	3.8 g
		Trans fat	0.4 g
Cholesterol	27 mg	Sodium	494 mg
		Potassium	192 mg
Total Carbohydrate	30 g	Dietary fiber	1.3 g
		Sugar	6 g
Protein	13 g	Vitamin A	1%
		Calcium	12%
		Vitamin B-12	13%
		Magnesium	5%

\*Percent Daily Values are based on a diet of other people's misdeeds.

Sources include: USDA

Feedback

Search results:

- Nutrition | McDonald's New Zealand**  
<https://mcdonalds.co.nz/maccaas-food/nutrition>  
 Nutrition. Know your food. You are what you eat, and you have a right to know. ... (To access the information below, use the scroll bar on the right hand side of the ...)
- Hamburger | McDonald's**  
<https://www.mcdonalds.com/us/en-us/product/hamburger.html>  
 Our hamburger has been with us since the beginning. The 100% beef patty is a ... menu item. You can also view the nutrition of an entire meal. CUSTOMIZE ...
- McDonald's Nutrition Calculator | McDonald's**  
<https://www.mcdonalds.com/us/en-us/about-our-food/nutrition-calculator.html>  
 Our nutrition calculator has the McDonald's menu nutrition information you're seeking. Learn more about your favorite meals.
- Calories in McDonald's Hamburger | Nutrition, Carbohydrate and ...**  
[www.calorieking.com](http://www.calorieking.com) > McDonald's > Sandwiches & Burgers  
 There are 250 calories in 1 burger of McDonald's Hamburger. You'd need to walk 65 minutes to burn 250 calories. Visit CalorieKing to see calorie count and ...
- McDONALD'S: Hamburger Nutrition Facts & Calories**  
[nutritiondata.self.com/facts/fast-foods-generic/80442](http://nutritiondata.self.com/facts/fast-foods-generic/80442)  
 Nutrition facts and information for McDONALD'S, Hamburger.
- Calories in McDonald's Hamburger and Nutrition Facts - FatSecret**  
<https://www.fatsecret.com/calories-nutrition/mcdonalds/hamburger>  
 There are 250 calories in 1 burger serving of McDonald's Hamburger. Get full nutrition facts for other McDonald's products and all your other favorite brands.

People also ask

- How many calories are there in a Big Mac meal?
- How many calories are in a Mcdonald's regular hamburger?
- How many calories is a small hamburger at mcdonalds?
- How many calories are in a small fry from mcdonalds?

Feedback

Figure 35: Screenshot of Google search for nutrition information in McDonald's hamburgers



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#### 7.2.2.4 *The function of the software*

Most of the software being used was not developed for educational purposes. The Suite software, Microsoft Word and Excel / Google Docs and Sheets / Apple Pages were not developed for students. The internet was not developed for students, nor were the browsers, search engines, or translation apps. Wikipedia was not, nor was YouTube or Vimeo, all of which were used in the classrooms. The school software, the learning management systems, were developed for education, but they are used more for management than learning (Castañeda & Selwyn, 2018). The students are working with real world applications in their real world. They are taking and using software in a way that was not necessarily intended by the developers.

Only a few websites were developed specifically for learning for senior secondary students in New Zealand. The three websites that were observed were NZGrapher, iNZight, and BestChoice for Chemistry. The Government investment in education through fibre infrastructures has not followed through to the downstream applications. NZGrapher is developed by a New Zealand maths teacher in his spare time and is not monetised; Jake Wills gets nothing from it “apart from seeing it used”<sup>20</sup>. iNZight and BestChoice for Chemistry are developed, hosted and run by universities.

#### 7.2.2.5 *Conclusion*

This section also shows tension between the activity theory nodes. On the one hand the information artefact is frequently provided by the teachers online, on the other hand wider access to information is blocked or discouraged. These sections on hardware and software are separated for analytical purposes, and it was shown that the hardware and software each have different tendencies and properties. It can also be seen that in practice

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<sup>20</sup> <https://grapher.jake4maths.com/>

the hardware and software are intertwined. The next section examines broadband.

### 7.2.3 Broadband

The use of broadband is ubiquitous in the classrooms. All the students in the study, except three, accessed the internet during class.

To access broadband the student necessarily uses software which is run upon hardware. It cannot be said that one is subsequent upon the other, ie, that the hardware is in the classroom to access the internet, or the internet is in the classroom because the students have laptops. That would indulge a techno-deterministic perspective and ignore the multiple stakeholders who have interests in education and / or technology. In critical realism social forms pre-exist, and it is into this technology rich environment that students enter and engage in activity (Bhaskar, 2005, p. 27).

The community, in the form of the school administration, affects the broadband. The schools select the school software (learning management systems) and the suite software (Microsoft, Google). These are cloud based applications and are accessed through the internet rather than on a LAN. Even when students are sitting next to each other the GoogleDoc they are working on together is in another country. In Section 7.4 it will be shown that the lessons are tending to be structured by the teachers to require the students to use online technology. It appears that students are inexorably tending to internet based work even when other options are available.

## 7.3 The objective of using the technology in the classroom

The objective is the motivation for the entire learning activity, and it was found that the motivation was to pass the NCEA assessment standard. The students who participated in this study are, arguably, those students who are doing well in the traditional school system. Nine of the classes are Year 13, the final year of secondary schooling in New Zealand; two of the classes are Year 12. All of the students are over 16. Schooling at this level is not

compulsory. Four of the eleven classes observed are STEM subjects: chemistry and statistics. Relative to all Year 12 and 13 students in New Zealand these students are more likely to go onto tertiary education and gain degrees (Education Counts, 2017).

In the interviews all of the teachers expressed the hope that the classroom experience would also have wider objectives. They expressed hope, *inter alia*, that the students would learn for their own pleasure, form lifelong learning dispositions, and have future opportunities.

In no class was the objective using technology. These observations firmly support equating the technology as the tool in activity theory: they place the technology as the secondary stimulus, identify that it may be auxiliary in learning, and that it may result in novel forms of learning, see Section 7.1.

### 7.4 The object of using the technology

In the findings which follow it can be seen that can be a *congruence* between the conditions which are available for the students operations, and the goals, that is the actions of the students. This is illustrated in an example drawn from the School A Year 13 History, when a student wants to talk to the teacher to discuss their work. The teacher's rule and classroom community conventions required the student to email the teacher to advise that they want to discuss their work. The conditions, which are the hardware, the email software, and the broadband connection to the internet, determined that the student is able to perform the operations which comprise the action of emailing the teacher. The teacher added the student to the list of students who want to discuss their work individually, and called the student up when it was the student's turn. This is a simple example of how a students' goal (to talk to the teacher about the work) results in the action (of emailing the teacher) which are composed of operations (typing and sending the email) which is determined by the conditions (the hardware, software and internet connection).

There are two things to note about this example. First, there is multiplicity. The goal (to talk to the teacher) can be achieved by a multiplicity of actions. In this example the student emailed the teacher, but the student is also able to put up a hand to attract the teacher's attention, or walk up to the teacher. Even in classrooms where teachers ask students to email they are able to and do use these offline strategies. When students do choose to email the teacher there is a multiplicity of operations which can achieve the same goal and action. That is, the conditions can vary. The students can email from their phones or laptops, and they can use a personal email or a school email.

Secondly, the students' actions are organic rather than mechanistic. A reductionist mechanistic worldview looks for separation and rational order. This research is finding relatedness and interconnectedness in activity, and a distributed, situated, embodied, dialogical, and dynamical nature of development (Stetsenko, 2008, p. 477). A discussion of what organic means follows in Section 9.3.3, but for now, it should be noted that the students perform these actions with little thought as to the operations. The students no longer need step-by-step instructions on how to send an email, they just do it. In terms of activity theory and the zone of proximal development, what was previously interpersonal has become intrapersonal. As the student who used the phone to write an essay said, "I just prefer it". This can be seen as an interaction driven by emotions and sentiments, rather than by rationality and efficiency.

In the examples that follow there is also plurality of effects, that is, the same hardware and software may be used to perform different actions. With the same conditions students can email their teacher, email their fellow students, share documents, write essays, create slides for a presentation, and play games.

It is also important to note that talking to the teacher is only one of many goals that a student will have in any particular class. The student will also need to read a document (composed of the operations of finding and

retrieving a document which is determined by the conditions, the hardware, software and internet connection), make some notes (composed of the operations of creating or finding and retrieving a document and writing which is determined by the conditions, the hardware, software and internet connection), write an essay (composed of the operations of finding and retrieving a document and then writing more paragraphs which is determined by the conditions, the hardware, software and internet connection), send or share the essay with the teacher (composed of the operations of sharing the document electronically or carrying the laptop to the teacher's desk which is determined by the conditions, the hardware, software and internet connection), and so on.

It is interesting to note that the same technology enables a student to write an essay and share that information with a teacher at the same time; thus in a single instant the information artefact can be both socio-cultural and physical, see Section 3.4. However, there was insufficient data to further investigate this phenomenon.

In the classroom, and this is not unique to classrooms with digital devices, the actions are composed of multiple operations for every task. Over the course of a lesson the student needs to read, think, write, share, re-write and perform many operations in order to learn. In this study alone, depending on the class, reading can mean reading books, documents, or subtitles. Reading can also be substituted by watching, listening, and experimenting.

Students will very rarely sit down in a class and do the same thing for the whole class. If they do, if for example, the whole class is watching a documentary, then it is not the only thing that they do. The teacher will stop the documentary to highlight important parts and check for understanding. The student will watch, take notes, and discuss the documentary.

In classes where students are working individually or in small groups then the student will read, think, write, share and so on, in the student's own time. *The student will bring together the conditions that the student needs to perform the operation.* As the operation changes, so the *students change*

*the hardware and software, ie, the conditions that they are working with. The student brings together the conditions depending on their function so that they can perform the operation.*

This change is not discrete and mutually exclusive. The students can perform multiple operations at the same time: ie, they can watch a documentary and take notes; they can write an essay and bring up a document for reference. Each individual student's actions in a classroom is different, and each student learns something different from fellow students engaged in the same classroom activities (Nuthall, 2012a, p. 98).

However, there are also times where there can be a conflict between the objective, the object and the operations. In School D Year 13 Chemistry (1) an example was observed which showed the learning focused on the NCEA standards. The objective of the activity was to pass the NCEA Standard 91391: Demonstrate understanding of the properties of organic compounds. A student wanted to use the word 'dehydrohalogenation' which he had found on Google. The teacher recommended using the word 'elimination'. Elimination reactions are important in the preparation of alkenes, and the term 'elimination' describes the fact that a small molecule is lost during the process. Two of the most important methods are dehydration (-H<sub>2</sub>O) of alcohols, and dehydrohalogenation (-HX) of alkyl halides. Elimination is a key chemical reaction which needed to be learnt; in terms of the information artefact it is an *explicit item of information* that the student needed to learn to pass the standard. The teacher recommended using chemistry vocabulary at the level of NCEA, rather than overcomplicating the process. If the student used the term dehydrohalogenation for alcohols in the exam then that would be incorrect, whereas the student could use elimination for both alcohols and alkyl halides. The student's resistance to using 'elimination' illustrated a tension between the objective (to pass the standard), the object (to learn the explicit item of information, elimination) and the operations (conducting a Google search). The conditions determine the operations (Section 3.2.3). In all of the teacher provided conditions, the information through the classroom activities, the notes on the learning

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management system, and in the class textbook, the explicit item of information was elimination. The condition that the student chose to use was the technology. Because the technology and information provided through that technology was not designed for senior secondary students in New Zealand, the operation that it enabled was not congruent for the student learning the object or achieving the objective.

## 7.5 The students' agency

The data reveal the students' agency in their own learning. Critical realism and activity theory both understand agency as the intentional satisfaction or "absenting" (Bhaskar, 1993, p. 112) of a need. The need is motivation of objective of the activity, or the goal of the action. The action may be more or less unconscious, and may be formed by the culture and the society in which the person lives.

The objective of the activity is identified as passing the relevant NCEA standard. Within that objective the student can perform multiple actions. To perform those actions the student selected the relevant technology components and *structured* them in an *ordered* way to fulfil purposeful, goal directed actions.

However, the technology imposes limitations on the students' agency. When the students were asked if they would prefer to work electronically or on paper there was a clear preference only for writing up work electronically (Figure 32). For the actions of taking notes, reading information, and developing a plan for written work there is a preference for working with paper over working electronically, although the ambivalent answer, it depends, is also prominent. The students are being moved to the technology artefact even when it is not their preferred mode of working, and even when, as will be shown in Section 9.4, the technology artefact does not support the learning action.

The ubiquity of the technology also means that it is very easy for the students to work with the technology, even if it is not the intended task.

This is illustrated in the following vignette from the School C Year 12 English class. The class was divided into small groups to produce collaborative work, which is an umbrella term for joint intellectual effort by students, or students and teachers together (Núñez, 2014, p. 13). In collaboration the group works together as a single mind, with all parties responsible for all aspects of the work, and participants contributing to the group answer.

The class was divided into 6 groups of about three students. The film they were studying had 3 main characters who were affected by a major event. The first part of the task was to discuss character development around the major event, so each group had one character, and had to answer questions about the character either before or after the major event. The teacher gave each group three questions on paper, which the students were to discuss, and told them to work together to “share the mind”. The second part of the task was for each group to share the notes with the whole class. The teacher suggested that each group should have a student acting as secretary to write up the notes, which could then be shared. The teacher estimated that the task would take up the whole 50 minutes of the lesson, however, the majority of the class finished this task in twenty minutes. Three different groups were observed, and they all worked in different ways.

In the first group there were four students, one person was writing up the notes. All the students discussed the text. They gave their opinion, listened to the opinions of the other students, and came to a conclusion that they all agreed on. This was written up on Google Docs by one student. For most of the exercise the students looked at the writer’s device, but by the end another student was using a phone to access the page on Google Docs. The notes were presentation as paragraphs. The students were still discussing the text and writing when they had to stop after 20 minutes, because all the other groups had finished. It appeared that they could have spent much longer on this task. This was the only group where the actions of the students converged with the teacher’s lesson plan.



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In the second group there were three students, all of them were writing notes on Google Docs. Each student added to all three questions at the same time. They did not alter each other's work, they added to it. There was little discussion. Early discussion centred on the technology: on auto save, "Everything I share on my drive is automatically shared with my home"; and on discussion of how to identify each other's work in Google Docs. The first discussion of text occurred 15 minutes in: one student commented that another's work was nice; another student said "the relationship one we should talk about". After a minute of typing the student says, "it is a love-hate relationship." That was their entire discussion of the task. Presentation was in bullet points. After 20 minutes the students had finished, and were changing the font, colour of text, and dropping in pictures.

The third group was again three students, again all three of them writing on Google Docs. The students divided the questions between them, each student had one of the three questions to answer. The middle student had a question, and asked the teacher for help. The student did not ask the other students in the group for help. Students were finished after 20 minutes.

Within each case, within each activity, within each action, within each operation there are differences and divergences between each student, and between the combinations of technology. Yet for each group the technology was combined in a *structured* and *ordered* combination, and the praxis that resulted from this agency was everyday learning. **The students' agency is the first mechanism identified in the event.**

## 7.6 Findings

From this interpretation of the data with activity theory it cannot be assumed that for any given event "there is a unique set of antecedent or concomitant conditions under which it is constantly conjoined" (Bhaskar, 2005, p. 95). As there are no *right* conditions it follows that,

... development and learning are not seen as products of solitary, self-contained individuals endowed with internal

machinery of cognitive skills that only await the right conditions to unfold. Instead, they are seen as existing in the flux of individuals relating to their world, driven by relational processes and their unfolding logic, and therefore as not being constrained by rigidly imposed, pre-programmed scripts or rules (Stetsenko, 2008, p. 477).

The students' everyday experiences with the technology in the classroom are fluid and varied, however five statements of the findings from this analysis are presented:

**1. The technology is spatially ubiquitous and temporally pervasive in these classrooms.**

As noted in Section 7.2.1 and Section 7.2.2 the hardware and the software are ubiquitous, spatially and temporally. There is a student preference for laptops over tablets, but in the observations it was noticed that students were comfortable working with whichever technology was available. The rules and norms of the community limit the hardware which is available, and there is limited specialist software for NZ secondary schools. *The tools that are available are circumscribed.* However, NZ secondary schools can be considered technologically rich environments.

**2. The students choose the combination of hardware and software to achieve their goals.**

Even though the technology available is circumscribed, *they still provide a field of possibility.* And within that field of possibility the students are generally free to choose and select the combination of hardware and software available. The way the students combine the technology is *purposeful* (activity theory), *significant* (T. Lawson, 2012), and *accountable* (Suchman, 2000). They don't just select whatever happens to be around and heap them together. Nor do they invent the technology. The components are

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built up, with experience and sometimes with difficulty, to a *structured* (T. Lawson, 2012), *ordered* (Suchman, 2000) combination.

In chemistry, history and statistics the students working on their assessment tasks were comfortable using either laptops or desktops for the same task. In one class, statistics, a student moved from a laptop to a desktop to complete the same task. In the same class some students used the graphing websites NZGrapher while others used iNZight. The teacher discussed the benefits of each website with the class as a whole, and two students discussed which website they preferred. The students arranged the composition of hardware and software with what was available to them, and which they preferred.

There are limits to this finding due to the rules of the classroom. For example, in one period in Chemistry the students were required to work through exercises in BestChoice for Chemistry. In the other Chemistry periods they were free to use multiple resources. But this observation shows an important point: the combination of technology that the students use is temporally linked to the task. Once they are finished with their exercises on BestChoice for Chemistry then they will stop using this particular combination. They may then move on to working in their SciPads (hardcopy workbooks), conducting general research through a search engine, creating a slideshow on a desktop, or creating (on a desktop) and participating (on a phone) in a Kahoot! quiz. Through all these operations the students are still learning Organic Chemistry, the object. For each object the students will create a combination of technology in their learning, and then it will dissipate. For the next step they will create another combination, and then it will dissipate.

The persistence of the combination of hardware and software is dependent upon the persistence of the task. In School B Year 13 History the entire 2-week observation was comprised of independent research of the students in the library. The dominant activities were conducted on the laptops and desktops, but the students would independently move to consult the teacher,

books or other students, or print off work on the photocopier. The teacher would query the whole class on progress at the beginning of some classes, and there was a whole class discussion on referencing their sources, but otherwise the students were constantly using technology.

In School B Year 13 Statistics the students were similarly on a task which required them to be using technology for the whole of the 2-week observation. In this case the students needed to use the NZGrapher website to work on their data, which was written up and submitted through GoogleDocs. There were breaks when the students emailed to be on the list for individual teacher assistance, and there was one small group discussion after which the students went back to working on their laptops and desktops.

In other classes there was a greater diversity of task types. In School C Year 12 English the students as a whole class created a word cloud on the blackboard, listened to and discussed a poem, as well as working individually on their laptops or on paper. It must also be remembered that in the majority of classes there are a range of non-digital resources available. All the students had paper and pens. In the history classes the students had access to books, handouts on paper and photocopiers. The students use all of the technologies that are available to them. This reflects NZ classrooms where teachers use multiple strategies and pedagogies in their classrooms.

### **3. The students' activity is not motivated by the tools; the tools mediate their activity**

The students are able and willing to move between hardware and software, and digital and non-digital technology, depending upon what is available and what they want to do. Thus it is difficult to claim that it is a particular hardware or software that is driving any learning activity. It is the object and objective of the task that is motivating the students, and they are able to use the range of digital and non-digital technology that are available to them to achieve their objectives. Within these actions and activities the technology may allow new forms of behaviour.

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#### **4. The tools need to be cognitively compatible to the action**

The highest number of responses for the question, What did you go online to do? were (a) note-taking, (b) reading teacher prepared information, (d) writing up work and (j) conducting a search. The first three activities, at least, are conducted in classrooms around the world, whether or not they are technology rich. What can be said is that the technology has the functions and capabilities to be used for note-taking, reading, writing and searching. These first three actions are fundamental to learning, and this discussion shows that the tools used by the students need to be cognitively compatible to the activity. This will be further elaborated in the next chapter which further examines cognitive goals of learning actions.

#### **5. The lessons are changing to require the technology**

In some activities digital technology must be used. For example, both statistics classes were studying the NCEA Standard 91581: Investigate bivariate measurement data. The key learning was to learn to use statistical tools to investigate bivariate measurement data. This assessment standard required that technology be used. The statistics teacher, whose degree was in statistics, advised that the statistical analysis to develop a model that underlies the question in the assessment is graduate level analysis. That is, it is beyond the level of development of the students. The students are required to find an appropriate model and use that model to make a prediction. Thus the students collect the data, input it into the technology, and learn to read the output – the trends, outliers and so on, without having to understand the tool beneath.

In media studies the students were required to search and view short documentary films to inform their understanding of visual techniques and language, which has to be done individually as it is project work. It is far easier to access multiple film resources as online digital files than as physical media.

## 7.7 Conclusion

These general findings show that for much of the day the technology is incorporated seamlessly into learning activities. The students' agency, the way they structure and order the combinations of technology, is the first mechanism identified in this thesis. From these actions there is plurality of effects, the same hardware and software may be used to perform different actions. With the same conditions students can email their teacher, email their fellow students, share documents, write essays, create slides, and play games. In the same class at the same time different students can be doing each of these things, yet the way they work looks exactly the same: sitting down at a keyboard and screen.

There are many different threads that run through the data. These threads are more than the findings from the data. The threads are traces of the social and philosophical explanations of the generative mechanisms that underlie the phenomenon, and which will be further elaborated in Chapter 9.

1. The hardware, software and internet access is *ubiquitous*. This is a spatial concept – the devices were everywhere. The devices are *pervasive* as most students had the devices to hand all the time they were observed. This is a temporal concept – the devices were everywhere all the time. The New Zealand high decile schools that participated in this study can be considered technology rich. The devices are ubiquitous because of community norms and school policies. During the research only two schools had BYOD requirements, but the other two schools are moving to requiring students to bring a device. Because the technology is there it will be used.
2. The students have access to multiple technologies. Each student used different hardware, software, apps and websites. The number of combinations of technology can increase geometrically, or even exponentially. There is *plurality of effects*, the same hardware and software may be used to perform a plurality of different actions.

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There is *multiplicity of causes*, the same actions can be performed in multiple ways with different technology. Thus there is not a unique set of antecedent conditions for learning with technology.

3. The object of the activity determines what combination of hardware and software the students use, given the conditions that are available. Every student is different. This means that the absence of learning is different for each student. Every learning experience is different. The student will choose a combination of hardware/software/apps/websites to fill the absence of learning.
4. Digital technology is used for reading and writing, and many other learning tasks: the tool must be cognitively compatible to the sign it is delivering.

These findings indicate that the use of the technology in the classroom is centred in, and dependent on, human behaviour and the agency of the students. This finding is echoed in activity theory (Kaptelinin & Nardi, 2006) and some critical realists (T. Lawson, 2015). The next chapter will use abductive analysis to reinterpret the data with Leontiev's hierarchy of activity to further investigate when technology is used for learning and instrumental purposes, and then Chapter 9 will use retroductive analysis to uncover the generative mechanisms behind this activity.





## Chapter 8 Hierarchy of activity analysis

Chapter 7 presented an interpretation of the data through redescribing it using the framework of activity theory. This chapter will present an interpretation of the data using Leontiev's hierarchy of activity. In critical realism using multiple theories to analyse the data can bring new insights and understanding to the data. In this section, through redescribing the data with Leontiev's theoretical lens the three *goals of learning actions* will be identified, being cognitive, instrumental and axiological.

Resolution and redescription of the data into the framework of activity theory began as soon as data was collected in the pilot study. However, there was data which did not fit neatly into the nodes of the activity theory triangle, and it became apparent that another framework could be used to redescribe the data, and that is presented in this section. This section will discuss in detail the steps of inference, from the data, to the redescription of the data into coding drawn from the data, through retroduction and elimination using social theories, to the development of the concepts of the three *goals of learning action: cognitive, instrumental and axiological*.

### 8.1 Facets of the tool

From the pilot study it was apparent that there were three main uses for the technology. This understanding of the technology reflects the origin of this

thesis in information systems, where *use* of technology is a core stream of research, and the original theoretical base of this thesis. It lead to an explanation that the technology was used for three purposes: cognition, distributed cognition, and metacognition. This was redescribed in Section 8.3 as goals of learning action, being cognitive, instrumental and axiological.

### 8.1.1 Cognition

Every observed action contained elements of learning, and a key purpose in the classroom is to learn the curriculum content. The students would read information online, complete worksheets online, and write up their work online. An initial label for these uses of the technology was *cognition*.

### 8.1.2 Distributed cognition

A concept of *distributed cognition* was developed to cover the extension of memory into the world, such as in text books and in note books. These are things that the students required the technology to do, and which align to those things that computers and the internet do really well: store, sort, retrieve, and connect.

It was observed that a common use for the devices is to store things. The teachers store documents for the students to access on the learning management system. The students store their notes on the learning management system. The students access their textbooks online. The students like the information storage provided by the technology because:

It is good to have all the information needed and my own files in one place

Because all the information is there on OneNote

There is a positive side of the ease of accessing the information:

Because I don't have to fossick through my bag

The students also had access to the wider information on the internet. They appreciated that:

I'll go online for other subjects if I don't understand. I'll find it through Google

There is so much information on the internet

It helps me find more information than what a teacher can provide

The students were aware of the capabilities of the devices, as one said:

Helps hugely for info / sharing info

The management of learning played a large part in every class, and emailing the teacher, sharing documents with the teacher, or accessing the learning management system was observed in every class.

### 8.1.3 Metacognition

*Metacognition* was a label used to encompass what the students think about the devices: how they value them as devices, and how they value them as devices for learning. Data supporting this was drawn from the questionnaires, where students identified the possibility of distraction with the device:

At times it can be a distraction

It can be hard not to go on stuff like Facebook

The students were also aware of, and considered in their thinking of, the devices in their learning.

I would much rather use books than computers

It can give background information but book work is better

It goes in better if I'm writing by hand, because I can touch type, and it is second nature and I can touch type

Here the students were considering metacognition, ie, thinking about using technology for thinking (Karpov & Haywood, 1998; Vygotsky, 1978). This shows that the students used a wide range of technology and non-technology to enable learning, and they were aware when technology let them zone out. Often it is assumed that agency is the ability to do something creative and unusual with the technology, but it must also include the empowerment of the individual to choose not to use the technology.

## 8.2 First iteration of the framework

The students appeared to be using the same tools for a many different purposes, and a conceptual framework was developed which involved a reconsideration of the nature of the tool in activity theory. The framework is presented in Figure 36, using the facets that were described above highlighted in green.

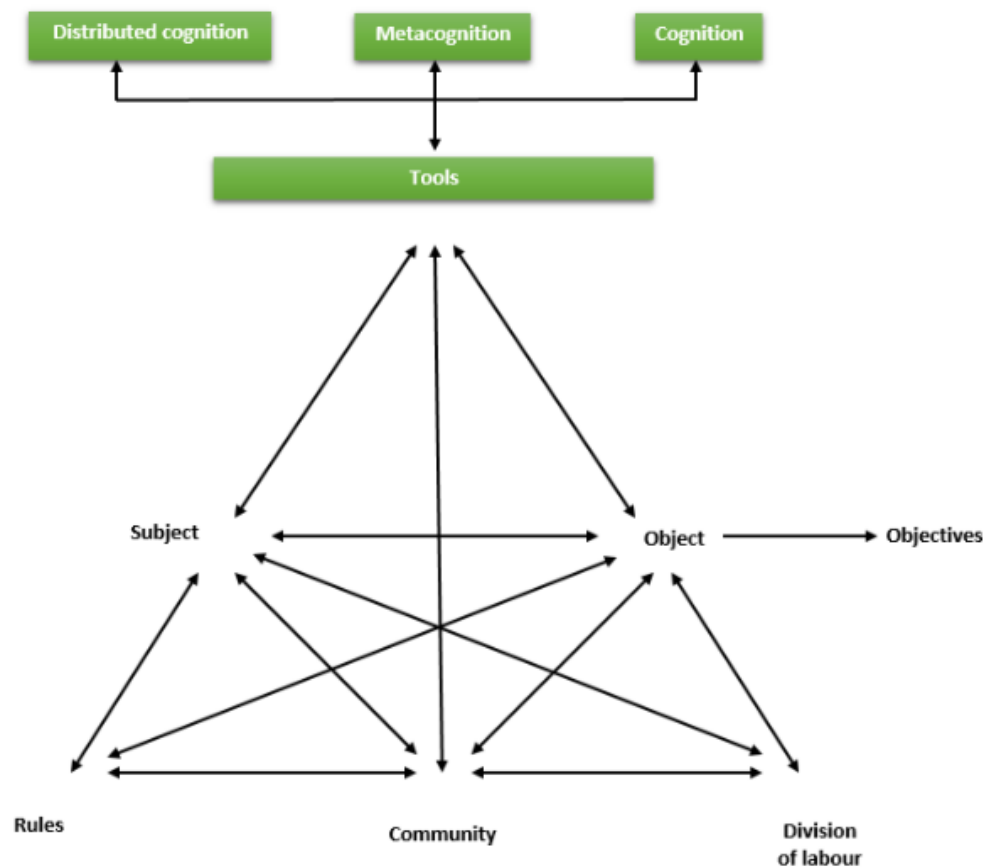


Figure 36: Activity theory triangle showing faceted tool of distributed cognition, metacognition and cognition.

This model had one positive aspect:

- It identified that the tool could be used for many different purposes and it had a plurality of effects.

This model had some negative aspects:

- The identification of the different facets was based on observation, but there was, at this stage, no conceptual framework to explain it.
- It positioned the tool as discrete from the user, and the object. It mediated the students' activities but there was insufficient connection between the nodes.

- It did not explain how the non-use of the tool could still result in the successful completion of the students' goals.

The next step was to consider the causal mechanisms through retroduction, ie, using theory to explain the behaviour, and eliminating the less rational alternatives.

### 8.3 Redescription of the data with different hypothetical frameworks

Other studies had identified different concepts which could be used to clarify and verify this framework. In activity theory Davydov, Slobodchikov and Tsukerman (2003, p. 72) identified three layers of learning activity: communication and cooperation, self-awareness, and thinking activity. Bødker and Andersen (2005) in computer mediated work identified two modes of use: instrumental and communicative, and cognitive. Núñez (2014) in critical realist activity theory identified expressive-performative, conative-affective, and cognitive modes of use in learning. Zinchenko, Pruzhinin and Shchedrina (2011), working on the purposes of tools in a cognate discipline to activity theory, identified pragmatic, axiological and cognitive. C Lawson (2010), working on theory of technology, identified extension of physical faculties, agents' will or intentions, and cognitive capabilities. Even with the breadth of research these modes of behaviour could be placed within three broad categories: instrumental, axiological and cognitive, which had broad equivalences to the facets on the original framework. This is summarised in Table 9.

8.3 Redescription of the data with different hypothetical frameworks

<b>Different modes of use of technology in the literature</b>							
	<b>Theoretical background</b>	<b>Label (broadly equivalent to first iteration)</b>	<b>Ontology</b>	<b>Instrumental (Distributed cognition)</b>	<b>Axiological (Meta cognition)</b>	<b>Cognitive</b>	
Davydov, Slobodchikov and Tsukerman (2003, p. 72)	Activity Theory	Three layers of learning activity	Relational	Communication and cooperation	Thinking activity	Self-awareness	
Bødker and Andersen (2005, p. 355)	Activity Theory	Aspects of activity theory	Relational	Instrumental, communicative		Cognitive	
Zinchenko, Pruzhinin and Shchedrina (2011, p. 56)	Human behaviour and activity	Types of human behaviour	Relational	Pragmatic	Axiological	Cognitive	
C. Lawson (2010, p. 208)	Theory of technology	Theory of extension of human capabilities	Object	Direct, mechanical extension of human physical faculties	Extension of human agents' will or intentions	Extension of cognitive capabilities	
Núñez (2014, p. 2)	Critical realist activity theory	Components of action	Relational	Expressive-performative	Conative, affective	Cognitive	

Table 9: Different modes of use of technology in the literature.

Through a consideration of these theories it was realised that the first iteration of the model was incorrect in many ways. First, it positioned the categories as facets of the tool. This was the same as Lawson (2010), but different from the other papers which placed them as activity, behaviour, or actions. It has been shown that the objective of the activity was to pass the NCEA standard, so activity was too high a level of categorisation. Actions are at more appropriate level, following Leontiev's hierarchy of activity. The first iteration of the framework and Lawson's model were eliminated, as the other models explained the data more closely. The data was then redescribed in the framework of *goals of learning action*, which could be *cognitive, instrumental or axiological*.

This redescription meant that each category would entail its own activity triangle, shown as Figure 37, with the change highlighted in orange.

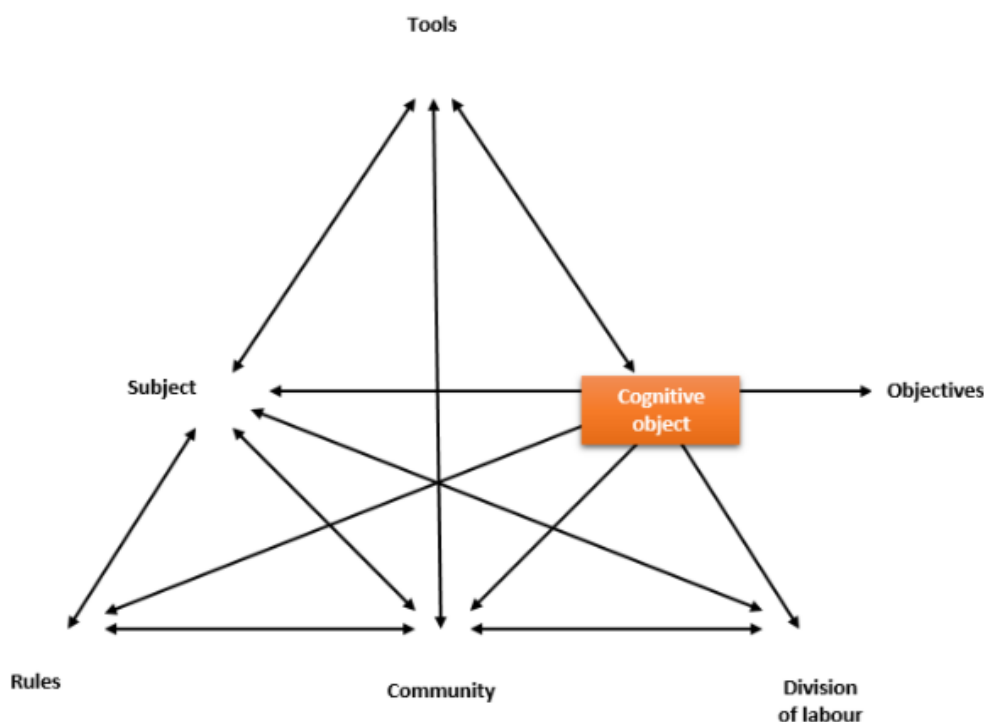


Figure 37: Activity triangle with recast cognitive object.

The first iteration had also identified the technology as a singular, with the possible outcomes as plural. Once the category was recast as an action, ie the cognitive action, the technology was no longer single but had



multiplicity of causes: different combinations of hardware and software could be used to perform the same action.

This model now aligned with both the data and the theory, and this understanding is key to the rest of the thesis. While there are three goals of learning action identified, cognitive, instrumental and axiological, this thesis will, from this point, focus on the *cognitive goals of learning action*, and how technology mediates these actions. These actions are called *cognitive* because they are the dominant goals, but all actions have cognitive, instrumental and axiological components (Zinchenko et al., 2011).

Axiological goals will not be further examined because there is insufficient data on students' motivation and other axiological considerations, as discussed in Section 6.2.3. Instrumental goals of learning actions will also not be examined further, as they are pervasive and brief, deeply intertwined with cognitive goals, and very hard to observe. The students store, sort, retrieve and connect with no problems, and these actions are almost invisible in the classroom: the student *cognitively* writes up the work and at the end *instrumentally* shares it with the teacher with the push of a button or the click of a mouse. Unless there is a *ping* of notification it is impossible to tell when the document has been shared or an email has been sent. In activity theory terms there are, generally, no contradictions or tensions to illustrate breaks in the activity. In terms of the information artefact it may be that the information needs to be considered from the physical stance, as information that is transmitted, rather than from the socio-cultural stance taken in this thesis (Section 3.4).

This thesis will focus on the cognitive goals of learning action, as there are breaks and tensions in the activity and the process is sometimes slow enough to be observed. This is the basis of the retroductive analysis in the next chapter.

## 8.4 Conclusion

The section showed the reasoning through which the three *goals of learning action* were identified as cognitive, instrumental and axiological. The threads that were identified in Chapter 7 are again picked up in this chapter.

1. The different types of learning were reframed as actions, not as properties of the technology. There is *multiplicity of causes* as different combinations of hardware and software may be combined to achieve the goal of the learning action.
2. The goal of the learning action, and whether it is cognitive, instrumental or axiological, determines the combination of technology.
3. The tool is used for achieving cognitive goals, so the tool must be cognitively compatible with these actions.

These threads are the traces of the philosophical and social theories that can indicate the generative mechanisms, the explanation that is the purpose in critical realism. In the next section retroductive inference is used to identify the causal mechanisms in play when students use technology in the classroom for learning actions, especially those which have cognitive goals.

## Chapter 9 Identifying the generative mechanisms

This chapter uses the third part of the RRRE methodological model, retroduction, to identify the generative mechanisms underlying the event. Retroduction asks what are the basic conditions for this event to occur, and this chapter shall focus on learning actions with cognitive goals. The questions are of the forms, *What properties must exist for X to exist and to be what X is?* and *What characteristics make X what X is?* (Danermark et al., 2002, p. 130) and *What must be the case for this event to be possible?* (Bhaskar, 1975, p. 29, 2005, p. 10).

In critical realism these questions are answered by referring to philosophical and social theories to make sense of the data. Theories are tools to highlight salient phenomena, make connections and interpret events. What theories will be relevant and able to do this can only be identified after the data has been resolved and redescribed, which was presented in Chapters 6, 7 and 8. This step in the methodological model is the fourth box in Wynn and Williams (2012, p.797) diagram depicting the relationships among the methodological principles. In that diagram the process of retroduction does not look back to the data, but uses theory to explain the newly redescribed phenomenon. Thus this chapter works with

the findings and the threads that have been identified, rather than returning to the decomposed data. It works with the patterns of the data, rather than the data itself, as it is the patterns that suggest the relevant philosophical or social theories that illuminate the generative mechanisms that are at work.

In this section the threads which have been running through this thesis will be highlighted. From these threads it will be seen that the technology artefact and the emergent information systems artefact and their roles as causal mechanisms need to be reconsidered. Three theories which can illuminate formal causes will be considered: Aristotle's causal mechanisms, a modern dynamic version of form and function (Roudaut, 2018), and functional organs from activity theory (Weatherby, 2016). These theories complement each other to recover the importance of form in information systems.

This section will identify that the technology artefact is an object, that *form* is intrinsic to that object, and that form has its own dynamism. It will identify the information systems artefact as an ontologically emergent category. In critical realism emergence is a process that entails both stratification and change, and has its own dynamism. This thesis argues that the emergence in this event can be understood as an *organising* of the technology, social, and information artefacts into the information systems artefact. This revindication of form, tools and emergence is proposed as an alternative to reductive materialism with deflationary accounts of objects and persons, where things are a collection of parts, or sociomaterial accounts where there is no difference between the social and the technical (Sarker, Chatterjee, & Xiao, 2013). It is an alternative where *form* structures *matter*, and can account for capacities and powers. At the end of the chapter a novel representation of the emergent information systems artefact will be presented based on the arguments in this thesis.

## 9.1 The technology artefact and causal powers

How the researcher understands the technology artefact is a direct result of the researcher's philosophy. Harman (2011, pp. 22–23) identifies nine different philosophical understandings of object, but this thesis will only discuss three of them before defining a realist account that draws from both Harman and Bhaskar.

- In a positivist, Humean account there are no objects, only 'bundles of qualities'. The object 'apple' is a label for a constant conjunction of variables: red, sweet, cold, hard, and juicy.
- In a Kantian, idealist account an object is 'what I think of it'. It is a correlate of thought, thus an object is nothing more than its accessibility to humans.
- In a relationist theory, such as Latour's actor network theory, the object exists through its relationship with other things, and is nothing more than its effects: how it modifies, transforms, perturbs or creates. An object is an actor but it is not an autonomous actor.

A realist<sup>21</sup> understanding of an object is that it is independent on its own account. An object is known by its relations, but it does not exist because of our knowledge of it; it is an independent thing outside our relations with it. Our understanding does not constitute its fundamental essence; our understanding is a consequence and effect of the object. This is not unfamiliar territory in information systems as Gibson's ecological approach to visual perception, or affordances, also contains this distinction (Gibson, 2014, p. 59),

Note that all these benefits and injuries, these safeties and dangers, these positive and negative affordances are

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<sup>21</sup> Both Harman's speculative realism and Bhaskar's critical realism.

properties of things *taken with reference to an observer*  
but not properties of the *experiences of the observer*.

In a critical realist account technology is an independent object. It may have been brought into existence through human activity, it may have a purpose for human activity, and it may change in the geo-historical context of society, but our understanding of the object does not exhaust all its possibilities. A student in New Zealand who conducts a search on Google is but a single event in all of the possibilities of the Google algorithm and the Google server farms, as is a discussion of Google in a thesis.

This section established that in a realist account of the world the technology artefact is an independent object, eliminating other accounts of the object. The next section will establish that an object is comprised of *matter* and *form*.

## 9.2 Matter and form of the technology artefact

A thread that runs through this thesis is shown the findings (p. 200),

There is *multiplicity of causes*, the same actions can be performed in multiple ways with different technology.

A way of stating this as a form of causality is that ABC or DEF or JKL will P. This is a disjunction of conjunctions. In this study an example is that a student can use either NZGrapher on a desktop, or iNZight on a laptop, and still complete the statistics task. This reinforces that there is a distinction between *form* and *matter*. The *materiality* of the technology is less important to the student than the *function* of the technology. This was first picked up in Chapter 2 where the full extent of the UFB over fibre rollout was not in the public domain, yet ultrafast broadband, both over fibre and cable, is available to the public: the materiality of the technology artefact was hidden, the functionality was not. It was further seen in Chapter 7, where the data showed that the students used a variety *of* devices, but were not interested *in* the devices; that they used the technology to achieve their

purposes. To understand the difference between form and matter this thesis next draws on Aristotelian philosophy.

### 9.2.1 Matter and form as the basis of the world and its explanation

The study of matter and form, in western philosophy, comes from Aristotle's contention that every object is a compound of matter and form. This doctrine is known as *hylomorphism*, a portmanteau of the Greek matter (*hulê*) and form (*eidos* or *morphê*) (Ainsworth, 2016). After falling out of favour in Western philosophy during the Enlightenment, hylomorphism is once again a topic of interest in philosophy (Jaworski, 2016; Koslicki, 2008; Marmodoro, 2013a, 2013b; Roudaut, 2018) and in information systems (Cheikh-Ammar, 2018). In the contemporary understanding of dynamic structural hylomorphism matter and form are both the *basis* of the world, and its *explanation*. This section will consider matter and form as causes through Aristotle's typology of causes, and then consider the nature of form.

### 9.2.2 Aristotle's typology of causes

In western philosophy central to the theory of causality is Aristotle's typology of causes. There are four classes of cause: material, efficient, formal and final, and to give a full account of an object each needs to be considered (Johnson, 2006). They will be discussed briefly before a more in-depth discussion of form as described by modern philosophy.

The material cause is what something is made of, eg, the bronze of a statue, the wood of a table. The material cause explains the general properties, so a wooden table will burn because it is made out of wood. The material cause has potential, because the wood could be made into a house. The formal cause is whatever gives something its definition or determination – the way that the matter is arranged. A fuller explanation of form is in the next section.

The efficient cause is that which brings something about, which is frequently called the agent. Multiple agents (and machines) can jointly form an efficient cause. The final cause is the purpose or goal, that for the sake of which an action was performed.

### 9.2.3 Caveats on causes

There is long-standing debate around the existence of real causes, as opposed to correlations which can be statistically inferred (Gregor & Hovorka, 2011), although it has been argued that the debate is more accurately defined as whether causation can be known (Harman, 2007).

There are some particular caveats on Aristotelian causes. First, the causes should not be taken individually, as a full account of nature needs to consider all the causes. The classic example of the sculpture has all four classes of cause: matter – bronze; form – horse; efficient – the sculptor; and final – to display the might of the city state. Secondly, the causes are intrinsic to the thing, and human uses and benefits are incidental to that thing. This is similar to object-oriented ontology (Harman, 2018) in that our use and knowledge of objects does not exhaust all possibilities of that object.

What this understanding of causation means for this thesis is that it is acknowledged that:

1. The consideration of the formal class of cause is only one way of considering the technology and the students' relationship to it.
2. It is not more valid than the classes of material and efficient causes, which are the dominant causes in information systems through, eg, sociomateriality and technology acceptance models, even if these are not framed within Aristotelian causes. However, Aristotle did acknowledge the explanatory primacy of the final/formal causes over the efficient and material causes.



3. There is confusion between form and matter, and the causal powers that are intrinsic to them. For example, Zammuto et al (2007, p. 752) state,

An affordance perspective recognizes how the materiality of an object favours, shapes, or invites, and at the same time constrains, a set of specific uses.

Yet Gibson specifically rejects materiality as a cause because affordances are *of the environment*, which includes what he “loosely call[s] objects” (p.57), behaviour, and places (p. 58). As the next section will show matter has causal powers as to its *being*, eg, a table that is wood can burn, a walking stick that is wood can burn. On the other hand *uses* are a function of form, ie, only a table can be used to put things on.

The next section will consider what form is, and how a dynamic version of form links form to function.

#### 9.2.4 Form as function with dynamic force

This section discusses a modern philosophical understanding of hylomorphism, which is inspired by the Aristotelian perspective. A modern definition of form is (Roudaut, 2018, p. 14),

Form refers to the internal principle of coherence in things, accounting for their unity, but also for their identity through time (an object A is identical with an object B if and only if they share the same numerical form). The distinction between integral and metaphysical parts allows the object to change according to its material parts without having its identity altered.

There is a common, but incorrect, assumption that form is equivalent to shape: that a table is a table because it is shaped like a table (Harman, 2011, p. 36). Nor is form equivalent to its category of objects (a table is a table

because it can be grouped with tables), its essential properties (a table is a table because it is table-like), or its physical relations between material parts (a table has four legs) (Roudaut, 2018). These are static conceptualisations, and form is not static but dynamic. An example which gives insight to this difficult concept is the child growing to an adult. With the concept of form (in an Aristotelian ontology) the child and the adult have the same form, the child *is* the adult. Both account for the essential properties which flow from form, both are unities of the essential properties which are unified by form, and synchronic and diachronic *identity* persists in spite of the ongoing generative change, ie growing up. A technology artefact example is that the 1965 IBM mainframe is a computer, and the 2018 Lenovo Yoga is a computer, even though materially they are quite different. The computer of the future will be a computer whether it is wearable, biological or quantum. The form persists, even when the materiality changes.

Roudaut argues that form is more logically considered as an organisational principle, or a dynamic structure of things, “More precisely, we must think about forms in terms of certain *functions* structuring things at a given moment and regulating them through time” (p. 22). Structure is a basic ontological principle: it concerns what things are. It is also a basic explanatory principle: it concerns what things can do (Jaworski, 2016). This is because structure is dynamic. Form, then, is an organising principle, that structures and regulates things through time.

### 9.2.5 Form as function with dynamic force in information systems

This understanding reconceptualises objects as having dynamic force. There is symmetry with activity theory, where activity is the form and essence of human life, and is an internal propelling force (Section 3.2.1). The dynamic force of objects, like affordances, can be both positive and negative. A person can express their agency through actions, but the technology can shape those actions: it can enable, resist or deflect actions. This is not through the agency of the technology, but because the technology, as an

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object, has the causal power to structure and regulate actions. **This is the second generative mechanism identified in this thesis.**

While this is not an orthodox position in information systems there are perspectives that come to a similar result through different means. Markus and Silver's (2008) spirit of technology through adaptive structuration theory, Markus and Silver's (2013) functional affordances, and Pentland and Feldman's (2008) grammar through actor network theory all posit a dynamic force in the technology. Outside information systems affordances (Gibson, 2014) and object oriented ontology (Harman, 2018) recognise structuring and regulating forces in objects (and non-objects). In critical realism there is equivalence with Roudaut's dynamic version of hylomorphism as Bhaskar wrote that causation is not a property of things but of the continuing activity of things (Bhaskar, 1975, p. 40). Activity theory is based on Marx's materialism, where the immanent causal powers of form are the basis for the theory of activity, and are implicit in the understanding of tool in Vygotsky's theory of mediation.

#### 9.2.6 Conclusion

This section provides a philosophical explanation for how form and matter account for the basis of the world. By recasting form as an organising principle it places form as key to the explanation of the world, and, specifically in this thesis, form as an organising principle. The dynamic form, or organising principle of the *technology artefact* is the second generative mechanism identified in this thesis. The next section considers the *information systems artefact*, which is an emergent, structured, organised, supervenient, processual totality, and form is essential to this process.

### 9.3 The information systems artefact

The information systems artefact in this thesis follows Lee et al (2015) and understands it as an emergent entity. This section will discuss emergence, and position the information systems artefact as an ontological emergent

totality. The information systems artefact comprises the technology, social and information artefacts. The thesis so far has elaborated on the form of the technology artefact, identifying form as a dynamic force. The next section will elaborate how the dynamism of the technology artefact is a component in the structuring of the information systems artefact as well. In critical realism emergence is as a process that entails both stratification and change, and has its own dynamism (Bhaskar, 1993, p. 32). That process is the third generative mechanism in this thesis, and is the subject of this section.

### 9.3.1 Emergence

Emergence simply means the appearance of something new, or something which was previously absent. There are a number of types of emergence, and this thesis will consider the two types discussed by Lee et al (2015): property emergence and ontological emergence.

*Property emergence* is the “side-by-side concatenation of a technology artefact, an information artefact and a social artefact” (Lee et al., 2015, p. 9), and thus not a true information systems artefact. A classic example is birds flocking. It is organised and has a characteristic shape. But it does not have any new causal powers, it merely enhances an existing power, which is flight, by decreasing wind resistance. A crowd going to a sporting or cultural event at a stadium is also an example of property emergence. It is organised and has a characteristic shape, and it may have efficient causal powers, eg, to hold up traffic. But the crowd is not created by the individuals and their actions, it is a response to pre-existing social structures and interactions. In Lee et al’s terms and in critical realist terms this is not correctly considered to be an emergent totality (Bhaskar, 1993, p. 30).

*Ontological emergence*, appears to be what Lee et al were considering when they talk about the information systems artefact. The classic example is H<sub>2</sub>O. The emergent totality, water, will extinguish a fire, while if the lower level parts are added to the fire they will either explode (H), or make the fire burn hotter (O). An ontological emergent totality is novel, and its

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causal properties are not reducible to the properties of its component parts (T. Lawson, 2012).

The question then arises about the *process* of formation of the emergent entity. The formation of H<sub>2</sub>O is a simple, linear process of chemical bonding as a result of the electromagnetic force of the individual atoms. In the open social system of the classroom there are multiple conceptual, social, and dialectical processes, and emergence is the outcome of multiple and changing mechanisms, agencies and circumstances. The results will be complex and differentiated, and the internal components, the artefacts, may be bonded onto a multiplicity of structures. These structures may be decentred, asymmetrical, and even have internal contradiction. They will be subject to the entropy of the real world, ie, they will *emerge* and *disemerge*; the higher-order level will decay, demise or disjoint. Moreover, the process is not teleologically driven; it is formed from the interaction of the component parts (Bhaskar, 1993, pp. 30–31). This conceptualisation of emergence evokes a roiling, tumultuous, almost inexorable event, but in the classroom these are quiet, easy events that happen tens, even hundreds of times in every lesson every day.

Social reality then is a *process*. The new level of reality is emergent if (T. Lawson, 2003, 2012):

1. it arises out of the relational organising of lower level components; and
2. it is dependent on the lower level for its existence; but
3. it has causal powers of its own, and these are irreducible to those operating on the lower level.

Social reality is emergent from human activity, with properties irreducible to the technology artefact or the social artefact, but capable of causally affecting both. The emergent totality does not exist independently of its component parts, and change is essential to its mode of being. It exists as a process of becoming and decline. It is dependent upon but irreducible to

transformative human agency, which was established in Section 7.5. The technology artefact is a dynamic component of the emergent entity. The technology artefact has intrinsic dynamism to structure and regulate, as established in Section 9.2.5. This structuring and regulating dynamism of the information systems artefact organises the lower level entities in the process of which the higher order entities emerge. This organisation is itself always a novel phenomenon, given the *multiplicity* of causes and the *plurality* of effects. The relational organisation is a higher level causal property of the emergent entity, and is also a form of formal causation. The causal powers of the information systems artefact to structure and regulate the technology artefact, the social artefact and the information artefact is the **third generative mechanism**.

Because emergence is formed from the interaction of the component parts the next section returns to activity theory for an understanding of that interaction and the organising structure of the whole, and through the concept of functional organs it will revindicate the tool as understood by Vygotsky. This step in retroduction seeks to explain the event and find the generative mechanism that forms the information systems artefact.

### 9.3.2 The tool in activity theory

The information systems artefact is composed of the technology artefact, the information artefact, and the social artefact. The technology artefact was conceptualised in Sections 9.1 and 9.2 in terms of *functions structuring* things at a given moment and *regulating* them through time. The information artefact was presupposed in Section 3.4. The social artefact was identified through activity theory, Section 3.2, and the unit of analysis, Section 4.3, defined as the students engaged in the learning activity, which was further bound in scope in Section 8.3 to students engaged in learning actions that had cognitive goals.

The question of how the technology artefact and the social artefact interact, or the tool and the subject in activity theory terms, is core to activity theory. The technology artefact and the social artefact are ontologically different,

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but together they form an emergent totality. The identification of the extent of the emergent totality and its boundary with the world in which it exists is an ongoing quest. Cole and Engeström (1993, p. 18) cite Bateson's 1972 thought experiment:

Suppose I am [blind], and I use a stick. I go tap, tap, tap.  
Where do I start? Is my mental system bounded at the  
hand of the stick? Is it bounded by my skin? Does it start  
halfway up the stick? Does it start at the tip of the stick?

Within activity theory there is a concept of functional organs which explains how the subject and the tool interact. Kaptelinin (1996) is the main proponent, but it is also referenced by Bødker & Klokmoose (2012), Raven (2006), and Vrazalic (2004). Kaptelinin notes that functional organs are derived from the work of Leontiev and goes on to say (1996, p. 25):

Functional organs are functionally integrated, goal-oriented configurations of internal and external resources. External tools support and complement natural human abilities in building up a more efficient system that can lead to higher accomplishments. For example, scissors elevate the human hand to an efficient cutting organ, eyeglasses improve human vision, and notebooks enhance memory. The external tools integrated into functional organs are experienced as a property of the individual, while the same things not integrated into the structure of a functional organ (for example, during the early phases of learning how to use the tool) are conceived of as belonging to the outer world.

In this interpretation functional organs are conceptually connected to the biological organ: hands, eyes, memory. This interpretation also has a normative element: efficiency, improvement, enhancement.

Contrast this with Zinchenko, Pruzhinin and Shchedrina's much wider conceptualisation of functional organs, "[a]n organ may be any temporary combination of forces that is capable of a certain accomplishment" (2011, p. 48). Here the tool is a force, such as an organising and regulating force as established in the previous section. For Kaptelinin the tool will only support and complement. Yet as was shown in Section 9.2.5 the technology artefact has force which, through its causal power to structure at a given moment or regulate through time, can enable or foreclose the actions of a person. Further, as a combination of forces the emergent entity is also a "force or even a combination of forces" (Zinchenko et al., 2011, p. 56) and the *organ* is the medium for representing it.

These conflicting conceptualisations of functional organs have very little literature associated with them. Every reference to functional organs in English uses Kaptelinin's definition, apart from Zinchenko's papers. Zinchenko has two papers in English, and all of Zinchenko et al's references are in Russian, except the French work of Jean-Paul Sartre, which is in English. While Kaptelinin's understanding derives from Vygotsky, Zinchenko et al reach back to the German philosophy in which Vygotsky worked, which is the next section of the thesis. There are researchers in activity theory who argue for a revisionist understanding to the concepts of cultural historical activity theory (Robbins, 2003; Yasnitsky, 2016): some because of the difficulties of translating Vygotsky from the original Russian to, for the most part, English (Kellogg, 2011; van der Veer & Yasnitsky, 2011); some because they consider the drift in theory from the original undermines the cohesion of the theory (Blunden, 2011; Veresov, 2005); and some to understand the larger historical and intellectual project and so continue to develop those ideas (Ratner & Silva, 2017). This thesis returns to the original German Romantic philosophers, as Blunden did to revindicate the concept of activity (Blunden, 2011).



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### 9.3.3 German romantic philosophy and how it shapes new conceptualisations

In activity theory a key principle is that activity is mediated by tools, both physical and semiotic. Modern interpretation of Vygotsky's work is coloured by the modern interpretation of tools. Today tools, and technology, are frequently seen as discrete tools, which can be picked up, used and discarded. Technology, especially the hardware, can be seen as neutral, or as a support or complement. There is symmetry with the dominant understanding of causation as efficient, ie, things happen because a person makes things happen, and they use tools to do it (Marmodoro, 2013b). This thesis argues that an understanding of tool during the 1920s and 1930s when Vygotsky was working was more complex. This conceptualisation of the tool is drawn from Engels, Marx and the German Romantic philosophers (Weatherby, 2016), and includes not only the cultural and historical genesis of the technology but also evolutionary, ecological and metaphysical aspects. This conceptualisation gives a rich understanding of the technology that students use in the classroom, and how they come together as the emergent totality which is the information systems artefact.

The difference between Vygotsky and modern interpretations is encapsulated with the term "organ" and its changing meaning. Now the word organ has strong biological connotations. During the time of Descartes (1596 – 1650) the word organs just referred to complex mechanisms, like tools or devices. A tool was shaped for its function, and the shape of the tool contributed to the outcome of its use. At that time it was the function of the tool that was key: the function subordinated the material. By the time of Leibniz (1645 – 1716) the organ was metaphysical.

The literal organ is both a physical location and a manner of operating, a set of rules: the location or part of the body performs a function with respect to the whole. By analogy, the "organ" is a set of rules for thinking and the

concrete application of those ideal rules—the ideal “organ” thus makes thought real and makes thinking efficacious (Weatherby, 2016, p. 16).

Here organs contain structuring and regulating functions. There still exists a trace of this thinking in the sense of newspapers, or television channels, being the “organs” of certain governing bodies.

Marx (1818-1883) also considered organs, and Vygotsky was working within the Marxist philosophy. Marx references Darwin and natural selection when he defines organs. In the following extract he talks about the diversity of task, and it is worth remembering here the finding that the students in the study use the technology for many different things (Marx’s Capital cited in Weatherby, 2016, p. 321):

And as long as the same part has to perform diversified work, we can perhaps see why it should remain variable, that is, why natural selection should have preserved or rejected each little deviation of form less carefully than when the part has to serve for one special purpose alone. In the same way that a knife which has to cut all sorts of things may be of almost any shape; whilst a tool for some particular object had better be of some particular shape.

In order to work humans have bodily organs, and also *organs* or instruments that are outside the body. The function of work requires a tool to execute the function. *The tools are identified as the historic signifiers of function; the function is only achieved by internal and external organs working in unison.* Thus it is not *using* tools that defines the human. What is important is the work that the organs allow, and that work is allowed through the technology artefact and the social artefact working in unison. The tool is the *ontological extension* of the human (Marmodoro, 2011, 2013b, p. 244). Functional organs are the tool and human together; they are functions and qualities, parts and wholes, and the history of their interactions.

### 9.3.4 Conclusion

The information systems artefact is the emergent totality of the technology artefact, the social artefact, and the information artefact. The technology artefact is the *ontological extension* of the social artefact, and together are the organising structure described as *functional organs*. The functional organs and the information artefact are organised into the emergent totality which is the information systems artefact. These are *organisations in process*. How this theoretical understanding of organisations in process and functional organs can explain the data is the subject of the next section.

### 9.4 Using the theory to explain the data

The information systems artefact emerges from the interaction of the functions and qualities of the constituent parts, the technology, information and social artefacts. This can be illustrated in Figure 38.

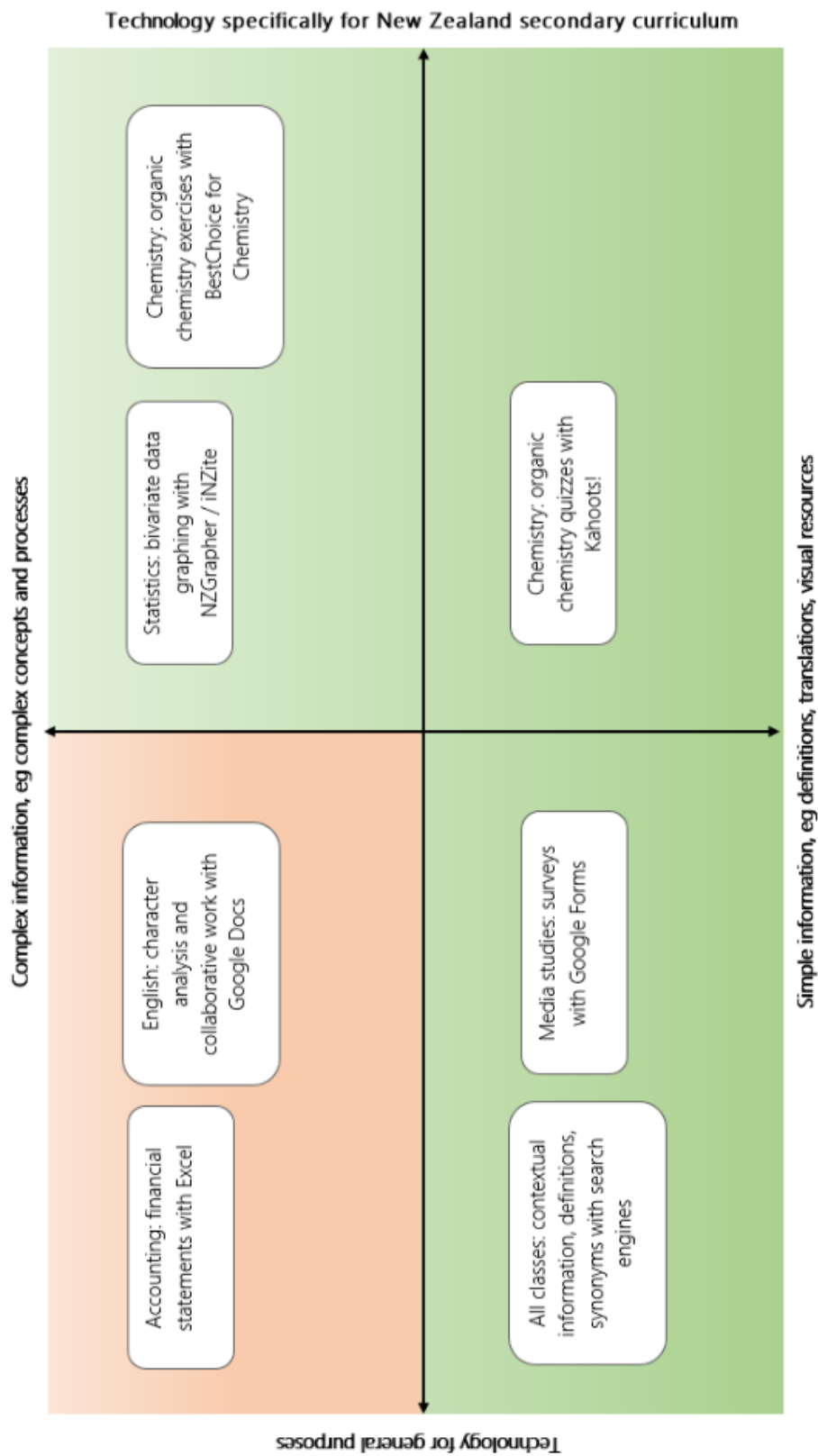


Figure 38: A representation of the emergent information systems artefact.

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In Figure 38 the information artefact is shown on the y-axis, from complex information at the top to simple information at the bottom. The y-axis is based on Nuthall's information items, which was presented in this study through the literature on the definition of information in information systems. In terms of activity theory the information artefact is equivalent to the sign, the psychological tool. Nuthall identified that some information items could be complex, such as complex concepts and processes, while some could be simple, such as definitions, translations and secondary visual resources like posters on the wall. Between these two options can be placed background, preparatory and contextual information, and instructions for relevant activities. Nuthall's items of information are items, they are not a scale, and so they do not have a fixed place or order on the y-axis. Where the information items are placed on the y-axis is dependent on the information and the students. For example, long multiplication is a very complex process for students in Year 3, but not for students in Year 13. Where the y-axis intercepts the x-axis is not defined.

The technology artefact is shown on the x-axis. The x-axis depicts technology which is for general purposes on the left, and technology for specific purposes on the right. The distinction between specific and general technology is drawn from the data, and elaborated in the retroduction section on functional organs. Technology that has been specifically created for the New Zealand secondary curriculum is to the right, and in the study that is NZGrapher, iNZight, and BestChoice for Chemistry. Technology created for general purposes that are used in the classroom is to the left, which includes search engines, and applications created for work purposes including Word and Excel and the Google equivalents. Kahoot! was created for schools, but not specifically New Zealand schools, and is placed towards the right of the axis. As with the information artefact the technology artefact are items, and how they fit on the graph depend on the technology and the students in the classroom.

The social artefact is the student who is performing a *learning action*. The student is required to perform an action in learning. For example, in School

D Year 13 Chemistry (5) in organic chemistry the students were reviewing previously learnt knowledge. This information artefact is a preparatory or contextual information item in Nuthall's coding, and can be considered reasonably simple for this class. The students organised their activity by choosing to use a Kahoot! quiz. The technology artefact was developed for educational purposes and other purposes, but is not specific to New Zealand secondary education. The technology artefact structured the actions that the students were able to take: they had to provide multi-choice answers; the students could not enter chemical equations or draw molecules, but they were able to insert images of molecules if they could find the right one on the internet. Together this is an emergent information systems artefact, represented in the bottom right quadrant of the diagram. In this quadrant there is unison between the artifacts and they work together to create an effective information systems artefact.

In the top right quadrant can be placed the *organisations in process* of students who are performing a learning action with a cognitive goal with complex information artefacts, using technology specific to the New Zealand curriculum, such as the statistics students studying bivariate data with NZGrapher; and also students working on organic chemistry with BestChoice for chemistry. In the top right quadrant there is congruence between the artefacts and together they work in unity to create an effective emergent information systems artefact.

In the bottom left quadrant are information systems artefact comprising students who are performing a learning action with a cognitive goal, with simple information artefacts, and general technology. In this quadrant are examples of students looking up definitions. In the bottom left quadrant there is congruence between the artefacts and together they work in unity to create an effective emergent information systems artefact. The general

congruence that was observed in this research leads to the three aforementioned quadrants being coloured in green.

In the top left quadrant are students working with complex information artefacts and general technology. In the study the accounting students who were trying to complete the financial statements in Excel are in this quadrant. It was observed that these students had to learn a complex process, yet they used software that was not written to achieve this purpose, and which hid the very processes that the students had to understand. In this event the technology prevented achieving the desired outcome, while non-use of the technology produced the desired outcome. In this particular event there was a lack of congruence between the different artefacts, they did not work in unity and the information systems artefact that did emerge had internal contradiction, and in the end disemerged. The students eventually worked on paper, which created another emergent information systems artefact, although not a digital one.

The students in English who were working on the character analysis on Google docs (which was discussed more fully in Section 7.5) are also placed here. The learning action with a cognitive goal was for students to interrogate their understanding of the characters through engaging in dialogue and working collaboratively, and then sharing their knowledge. One group of students discussed the characters (interrogate their understanding) and then wrote up their work in Google Docs (share their knowledge). The other groups presented wrote in Google Docs (share their knowledge) without discussing the characters. For the same task there were different processes between the groups. The teacher considered that for all groups the final product was adequate, but for three groups a step that the teacher considered vital (“share the brain!”) was omitted. Technology is considered collaborative if it allows students to work on the same document at the same time. Learning is considered collaborative if students work together to discuss and interrogate the information and their knowledge. The outcome was sufficient but a vital purpose was not achieved. In this event there was some congruence between the object of the social artefact,

the information artefact, and the technology artefact, but it was limited. Information systems artefacts emerged, but three of them were partial totalities.

In the top left quadrant learning actions can be achieved successfully. However, consideration needs to be given to the complexity of the information items being learnt and the specialisation of the technology artefact, to ensure there is congruence between them to enable a unity of action. It is because of these conditions that this quadrant has been coloured orange in the figure.

It must also be noted that learning actions performed in the classroom are within the students' wider activity of learning over time for the objective of learning and passing the NCEA standard. The learning actions cannot be seen in isolation, and they are not entirely digital. In the Kahoot! quiz example the students had already worked with their teacher and their peers to learn the information that needed to be reviewed. While the students were developing their quizzes they were working together in groups, and the teacher was answering their questions. When the students were presenting the quiz to the class, and the other students were competing to answer the questions, the teacher would frequently stop the proceedings to talk to the students to clarify information, and would identify opportunities to extend the students' knowledge. The later classes that built upon this reviewed knowledge allowed further opportunities for the students to experience this information.

### 9.5 Conclusion

The purpose of this chapter was to identify the generative mechanisms that underlie the events experienced through retroduction. The first generative mechanism was the students' agency, identified in Section 7.5.

The form of the technology artefact includes its purpose. In achieving the purpose the technology artefact has the dynamic causal power to structure



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things at a given moment, or regulate things over time Section 9.2. This is the second generative mechanism.

The information systems artefact is a structured, emergent, goal-directed entity, discussed in Section 9.3. The information systems artefact exists as a process or organisation, of becoming and decline, of emergence and disemergence. This social reality emerges from the activity of the students.

The actions of the students have cognitive, instrumental and axiological goals. To achieve these goals the student will structure certain objects into a functional entity. When the student uses the technology artefact in a learning action to achieve a purpose the student and technology together can be described as a functional organ: together they are a functionally integrated, goal-directed configuration of internal and external resources. The functional organ can be for a single, special purpose, or it can perform diverse works. As the functional entity is goal-directed (in activity theory, contra homeostatic in systems theory) the functional entity will only exist until the achievement of the goal, or the realisation that the goal cannot be achieved. This is the revindication of the tool in activity theory, from the data and theory described in these chapters.

The cognitive object/purpose requires that the information artefact, the social artefact, and the technology artefact are congruent and work in unison. The information systems artefact can be described with the metaphor, an *organisation*. The organisation comprises the student, the technology and the information. The technology has form and function. The organisation is an emergent totality that has form. It is the student, within the parameters of the rules, the community, and the division of labour, who structures the organisation. Parts of the organisation, specifically the technology, can be upgraded or swapped out and new organisations will form; digital technology can be replaced by paper and pen and new organisations will form. The organisation will only last until the purpose is achieved, it is goal directed. The purpose is for the student to *learn* the information, in all the different ways that can mean. The purpose is the

student and the information in unison. The organisation will only achieve its purpose if there is congruence between the human thought process and the technology's computational processes. The organisation is the emergent information systems artefact; it is the way of working of the technology artefact, the information artefact, and the social artefact. The causal powers of the information systems artefact to structure and regulate the lower level entities is the third generative mechanism.

A parsimonious explanation that combines the three generative mechanisms stated above is,

**The possibility of learning with technology depends upon the cognitive congruence of human thought and computer processes during synchronic, purposeful ordering.**

## Chapter 10 Conclusion

This thesis aimed to understand technology in the classroom as part of the lived experience of the student. It acknowledged the multiple stakeholders who are interested in the technology in the classroom, and the conflicting pressure and advice from the academy, government and technology providers. These divergent opinions were reflected in the divergent academic literature on the purpose and the practice of technology in education. Against this background the teachers and students were quietly getting on and figuring out when and how to use the technology that was in their classrooms in their learning. The study was driven not by theory but by these ongoing, ordinary, everyday events. It was designed to collect rich data about the students' experiences through asking the research questions, **What is the technology artefact that the students are using in the classroom?** and **How do students engage with the technology artefact and the information artefact in the classroom?** The data collected captured the nuances and contingencies of the students' everyday choices and experiences, and the knowledge that they gained from these experiences. Once the data was collected then theories from philosophy and social sciences were used to reframe this data, to identify the causal mechanisms involved. The first causal mechanism is the agency of the student. The second causal mechanism is the form and function of the technology to structure and regulate activity. The third causal mechanism is

the processuality of the emergence of the information system. This interpretation led to the revindication of the tool in activity theory.

This final chapter presents a summary of this journey, and then considers how these findings contribute to theory in information systems and to teachers' practice in the classroom. The limitations of this study are acknowledged, and the thesis is concluded by offering suggestions for areas for future research.

### 10.1 The open information system

This thesis has been structured by the understanding that technology in education is a social phenomenon in an open social system. The openness of the system means that the conjuncture of technology and education occurs on many levels, and the multiplicity of causal powers and liabilities precludes making certain and precise predictions. This impacted on the research approach in two ways. First, the research questions needed to be broad enough to collect rich data to fully explore the open system, to capture the nuances and contingencies of the everyday lived experiences of the students, and the complex interactions between the student, the technology and the information.

Secondly, the philosophical and theoretical frameworks that structured the research design needed to be comprehensive and robust enough to encompass open systems and their unpredictability. Both critical realism and activity theory were specifically developed to address real, open world problems. Activity theory places the classroom as a collective, artefact-mediated and object-oriented activity system, seen in its network relations to other activity systems. Goal-directed individual and group actions and operations are independent but subordinate units of analysis, which enable analysis at multiple levels. Similarly, in critical realism there are multiple categories, or rhythmic processes, which designate the specific process of the exercise or impact of the causal powers of structures or things at multiple levels. At whichever level(s) the conjunction between technology

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and education is studied the interaction between people and the technology is different, and both critical realism and activity theory are robust enough to be able to account for multiple conjunctions and multiple levels of analysis. Activity theory was used to structure the research design, and analyse the data.

This thesis did not follow the dominant epistemic script in information systems, but the critical realist methodological model of explanation, RRRE (Bhaskar, 1975, 1986, 1993, pp. 74–75). In an open system multiple things act upon multiple other things, and there is no reason for the past to resemble the future. What we experience or observe in the world may not be *all* of the relevant events, and may not be the *entire* relevant event. The empirical data is not considered proof of a stable and objective reality but one possible instantiation of mechanisms. In the critical realist script abductive reasoning uses multiple theories to frame the data in different ways, and retroductive reasoning uses philosophical and social theories to propose some generative mechanisms behind the data. This philosophical understanding of the world guides the research design and the data analysis.

## 10.2 The data and findings

The first research question, **What is the technology artefact that the students are using in the classroom?** was asked because the technology in the classroom and the configuration of that technology is unknown (Section 2.4.1). While in studies in New Zealand the technology has often been assumed (Melhuish & Falloon, 2010) or forecast (Sweeney, 2012) this researcher took the position that in a study examining a naturally occurring phenomenon in an open system the technology, being the hardware, software and broadband connectivity, used by the student needed to be identified. The data was presented in Chapter 6, *resolved* into the separate components of the activity theory triangle using deductive reasoning based on coding from activity theory, Lee et al's (2015) analysis of the information artefact and technology artefact, and Nuthall's (Nuthall, 2001b) items of information.

All of the students in this study had access to broadband connectivity (Section 6.7). In the BYOD schools all students owned multiple devices (phones and laptops) that could connect to the internet. In the non-BYOD schools all but three students had access to devices (phones, laptops, tablets and desktops) that could connect to the internet. These were a mix of student owned and school supplied devices. The schools provided the instrumental school software (eg, the learning management system and printing system) and the suite software (eg, Microsoft suite and Google suite) that the students were required to use. The software that the students used for cognitive tasks varied between whether the software was specifically designed for the New Zealand education system (eg, NZGrapher), and general software (eg, search engines). The more specific the software was the more likely that it was compulsory (the chemistry students *had* to complete the exercise on the BestChoice for Chemistry website), or they could choose between the software (the statistics students could use either NZGrapher or iNZight).

The second research question asked **How do students engage with the technology artefact and the information artefact in the classroom?** This question was asked to identify how the technology artefact (as identified through RQ1) and the information artefact (as identified in section 6.8) were used by the students in the classroom. In critical realist terms there are multiple steps in answering this question. First, the structure and context of the phenomenon, that is the connections and interdependencies of the artefacts, must be identified (Section 3.1.2). These were discussed in Chapters 7 and 8, and are further elaborated below. However, an explanation at this level explains the phenomenon in terms of the domain of the empirical. In critical realist research the purpose is to explain to generative mechanisms, ie, the transfactual conditions in the domain of the real; this is discussed in Chapter 9.

Chapter 7 considered the relationship between the technology artefact and the rules, the community and the division of labour. It identified that the technology available to the students is contingent on the rules and the

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community of the school. It showed that it was not the technology *per se* which was driving the activity, as what the technology *could do* was more important to the students. The key findings from Chapter 7 are:

1. **The technology is *spatially ubiquitous and temporally pervasive in these classrooms*.** Most of the students had devices to hand at all places and all the time. The devices that are available and how they are used are circumscribed by the rules, the community and the division of labour in the school.
2. **The students choose the combination of hardware and software to achieve their goals.** The students select the technology components they need to achieve their goals which are built up in a *structured* (T. Lawson, 2012) and *ordered* (Suchman, 2000) combination.
3. **The students' activity is not motivated by the tools; the tools mediate their activity.** The technology does not drive the students' learning activity, but it does mediate the activity, allowing the students to create new forms of behaviour.
4. **The tools need to be cognitively compatible to the action.** The tools are not just being used for simple tasks, such as storing notes or emailing the teacher. They are being used for reading and writing, which are actions fundamental to learning. The tools need to be cognitively compatible to the students' actions.
5. **The lessons are changing to require the technology.** In some classes digital technology must be used. In Statistics the students *have* to use online tools; in Media studies it is implicit in the requirement that they view multiple short documentary films.

These findings show that within the constraints identified through the rules, community and division of labour, the students *select, structure and order* the technology to fulfil their purposeful, goal directed activity.

This chapter also identifies four threads that will continue through the following interpretation chapters.

1. The technology is ubiquitous and pervasive.
2. There is *plurality of effects*, the same hardware and software may be used to perform a plurality of different actions. There is *multiplicity of causes*, the same actions can be performed in multiple ways with different technology. Thus there is not a unique set of antecedent conditions for learning with technology.
3. The object of the activity determines how the students select, structure and order the hardware and software, how they combine them into the technology artefact, given the conditions that are available.
4. The tool of the digital technology must be compatible to the information that it is delivering.

In Chapter 8 the data was redescribed using Leontiev's hierarchy of activity framework. This chapter moved from the level of activity to the level of actions. This chapter identified the three *goals of learning action*, which are cognitive, instrumental and axiological. This chapter again picked up three of the threads.

1. There is *multiplicity of causes*: the different goals of learning are achieved through action, not through properties of the technology, and different combinations of hardware and software may be combined to achieve the goal. This refines the second thread above.
2. In Leontiev's hierarchy of activity terms, the object of the activity is to achieve a goal of learning action. It is the goal of the learning, and whether it is cognitive, instrumental or axiological, which determines the combination of technology. This refines the third thread from above, and establishes the students' agency in their learning actions.



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3. The tool is used to achieve cognitive goals, so it must be cognitively compatible with these actions.

These chapters identify that students have agency in their learning, which is the **first generative mechanism** identified in this thesis (Section 7.5).

Chapter 9 uses retroduction to identify the causal mechanisms underlying the event. Retroduction uses theory to interpret the resolved and redescribed data, and it is only through the data that the relevant theory can be identified. The golden thread that runs through this thesis is that in the classroom there is *multiplicity of causes*, the same learning actions can be performed with multiple configurations of different technology. This was first picked up in Chapter 2, where because of commercial sensitivity the full extent of the UFB fibre network was not in the public domain. The providers offered ultrafast broadband over fibre or cable, or over a combination of them. The materiality of the technology artefact is hidden; the functionality is not. It followed through Chapters 7 and 8, where all types of technology could be used to achieve a learning action: essays were observed being written on phones, laptops and desktops; students could access their documents on Google or Microsoft suite software. It was the function / form of the technology that was relevant to the students, not the matter.

This thesis identified three theories which illuminate the difference between form and matter, and thus the generative mechanisms behind the experienced event. The first was Aristotle's typology of causes. Of the four causal mechanisms matter and form are both the *basis* of the world, and its *explanation*. The *matter* of technology artefacts has been explored in information systems through sociomateriality, the *form* of technology artefacts has been less considered.

The second theory is a modern definition of form (Roudaut, 2018), that it is a dynamic, organising principle that structures things and regulates them through time. The dynamic causal power of the technology artefact to structure things at a given moment, or regulate things over time is the

**second generative mechanism** (Section 9.2.5). Chapters 7 and 8 established the students' agency, this chapter established that the technology also contributes to the causal process through its dynamic form.

How these processes work together to create the information systems artefact is illuminated in the third theory, emergence. Emergence is the outcome of multiple and changing mechanisms, agencies and circumstances, which bond into a multiplicity of structures, which will emerge and disemerge because they are part of the real world. These are the constant, changing actions that happen in the classroom every lesson and every day.

The nature of the tool in emergence is finally considered through the fourth theory, the activity theory concept of functional organs, which provides an understanding of how the social artefact interacts with the technology artefact, how the student uses the tool. This thesis finds that it is not using tools that defines the human. What is important is what can be achieved with the tool. The students' object of the activity is to achieve the goal of the learning action, which can happen when the student and the technology work in unison, given their functions and qualities, their relation as parts to the whole, and the history of their interactions.

This thesis uses the metaphor of an *organisation* to describe the emergent totality of the information systems artefact: the way of working of the technology artefact, the information artefact, and the social artefact. This is the **third generative mechanism** (Section 9.3.1).

Through applying the insights from these theories to the data this thesis developed a framework which is presented in a two by two matrix, with intersecting axes of the technology artefact and the information artefact, in which instantiations of the *organisation* of the student could be placed, and which is presented again, Figure 39.

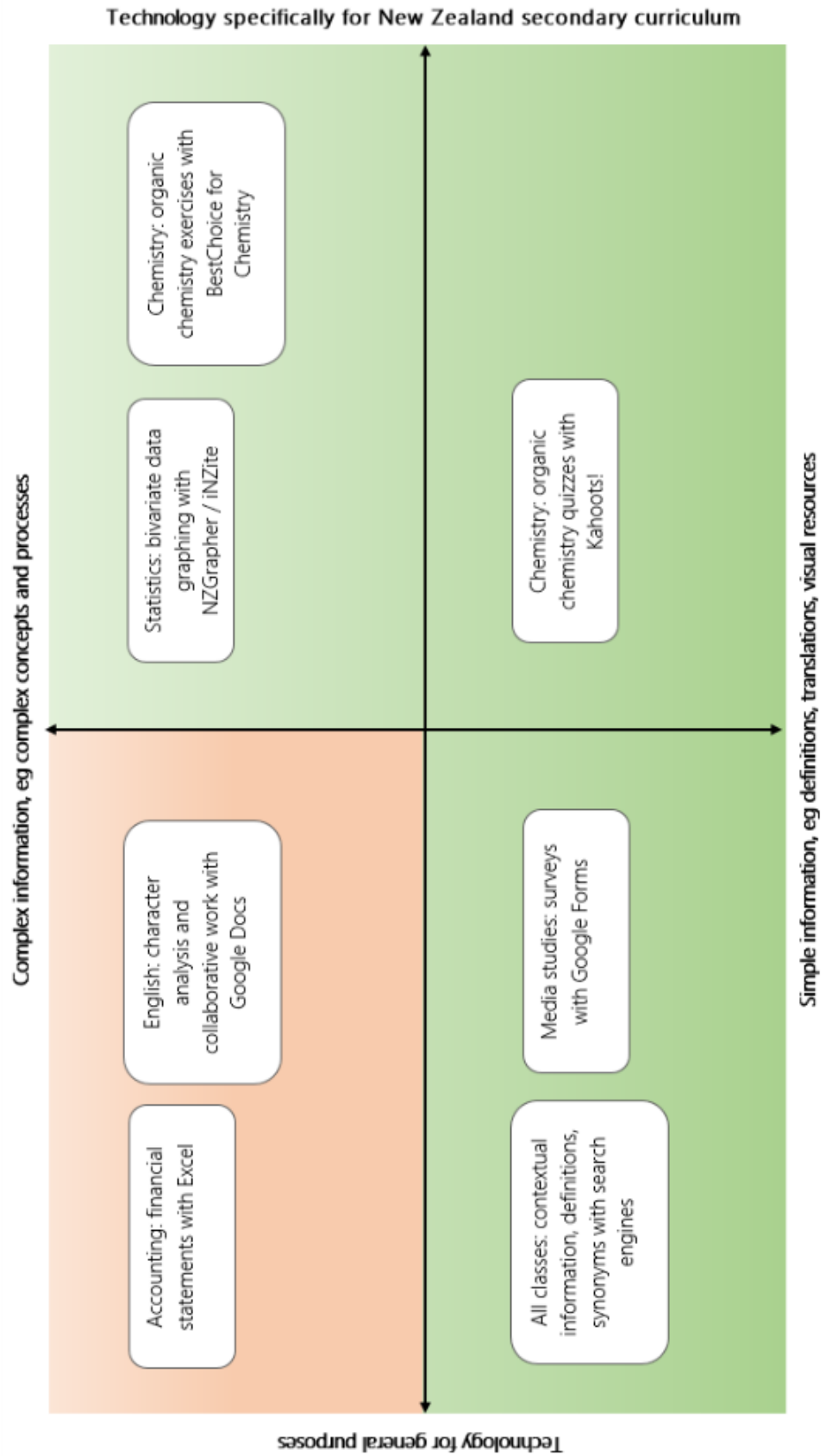


Figure 39: A representation of the emergent information systems artefact (reprise).

The four quadrants show that where the information is simple, then the student can create an organisation with a multiplicity of technology, and the goal of the learning action can be achieved readily. In the quadrant where the information is complex then if the student uses specialist technology then the outcome is also likely to be successful. In the quadrant where the information is complex, and the technology is not specific, then there may be a lack of unison between the information and the technology, and care should be taken in learning actions in this quadrant.

The answer to the second research question **How do students engage with the technology artefact and the information artefact in the classroom?** is as broad as the question is. The thesis sought to identify the generative mechanisms through a retroductive account, which asks what must the world be like for all this to make sense. A parsimonious explanation is that:

**The possibility of learning with technology depends upon the cognitive congruence of human thought and computer processes during synchronic, purposeful ordering.**

The student, the technology and the information is a union of its parts. It is purposeful, goal-directed activity to achieve the goals of learning action. It happens many times a day in many different permutations. It is the unity of purpose and function, and unison of execution, that allows for the possibility of learning.

### 10.3 Contributions from the thesis

There is a dialectical relation between theory and practice and this thesis contributes to both. This thesis contributes to information systems through novel understandings of the information systems artefact and the technology artefact, and the application of philosophy in information systems. This thesis contributes to practice through providing a matrix which can guide teachers in their use of technology in the classroom.

### 10.3.1 Theoretical contribution to the information systems artefact

An information systems artefact has been defined as an emergent totality (Lee et al., 2015). This thesis has used the theories of emergence and functional organs to identify that an information system is not the information technology alone, but the totality that emerges from the mutually transformational interactions between the technology artefact, the information artefact and the social artefact. This emergent totality is represented in this thesis by the metaphor, *an organisation*. The student, within the parameters of the rules, the community, and the division of labour, structures the organisation, choosing and matching technology to the information. Different parts of the organisation can be upgraded or substituted, yet the organisation will endure, at least until its purpose is achieved. The organisation will only achieve its purpose if there is congruence between the human thought process and the technology's computational processes. The information system is not just an information technology enabling an organisation, it is also an organisation enabling an information technology (Lee, 2004). This understanding of technology in education sees the artefacts as existentially constituted.

This understanding has been developed specifically in the context of education, and is represented in Figure 39. The axes have been specifically developed for information artefacts and technology artefacts that are found in the classrooms, and the information systems artefact that emerges when the students have cognitive goals in their learning actions. However, the generative mechanisms, the agency of the individual, the form and functionality of the technology, and the processuality of the emergence of the information systems artefact are the factors which, in the real genesis of the event, produced the outcome. These mechanisms can be applicable in wider information systems theory.

### 10.3.2 Theoretical contribution to the technological artefact

This research contributes to the ongoing consideration of the technological artefact in two ways. First, core to this thesis is theorising the technological artefact. It draws from contemporary theory of Aristotle's hylomorphism to allow that the technological artefact has both matter *and* form. It presents form as a dynamic, structuring process. Technology has the causal powers to organise, through its power to structure and regulate actions.

Secondly, it identifies that functional causation and material causation occur at different levels: the functional at the level of actions, and the material at the level of operations. This identifies the complementarity of a functional perspective with a sociomateriality perspective.

An exploration of hylomorphism, and especially form as a dynamic, structuring process, offers a path to consider questions core to the IS discipline: how can we conceive of the technological artefact; how can we conceive of the information artefact; how do these artefacts interact: how do information systems artefacts emerge. How the technological artefact is conceptualised leads to a consideration of the causal properties of the artefact. These are difficult ontological questions, but it is hoped that these perspectives, and debate on these perspectives, can contribute to theoretical perspectives in the IS discipline.

### 10.3.3 Activity theory

This thesis reconsiders the tool in activity theory by drawing on the Romantic philosophy which informed both Marx's philosophy and Vygotsky's work. The understanding of functional organs and functional systems is key to this reconceptualisation. This conceptualisation reorients the understanding of the tool by ontologically extending the organism to include the tool and then into the environment, rejecting Cartesian dualism, and considering the human and the technology as an organisation.

#### 10.3.4 Philosophy

Critical realism is increasingly being positioned as one of the three main philosophical viewpoints along with empiricism and interpretivism. This thesis offers an example of an application of critical realism in information systems, and contributes to the methodological implications of critical realism. Critical realism is strongly placed to “push the edges” of information systems research (Grover & Lyytinen, 2015), as it requires data driven research that observes new emergent phenomena, and it requires strong theoretical consideration through its abductive / retroductive reasoning which challenges research to make surprising connections (Williams & Wynn, 2018).

#### 10.3.5 Contribution to teachers’ practice in the classroom

This thesis hopes that Figure 39 will provide teachers with a useful guideline which they can adapt to their own classrooms (Nuthall, 2004). The figure suggests three questions teachers could ask when they are using technology in their teaching:

1. **What type of information will the students to engage with?** In the figure information item types are represented on the y-axis, ranging from simple to complex information. There are seven item types of information (Nuthall, 1999): explicit and complete, implicit or partial, additional or explanatory, preparatory or contextual, key words, a process, instructions, and relevant visual resources. The most complex information item types are conceptual and processual knowledge, and students are required to engage deeply and critically with this type of information. These are placed higher on the axis than simple information items. It needs to be noted that this is not a scale and the placement of the information items is dependent on the context.
2. **What type of technology is available?** The technology is represented on the x-axis, ranging from technology for general

purposes, to technology for the New Zealand secondary curriculum. In this study the technology that allowed critical engagement with high level information at both levels was based on software that was specifically written for New Zealand secondary students – NZGrapher, iNZight in statistics, and BestChoice in chemistry. Generic software, such as word processing and spreadsheet software are tools that have wider functionality, and are less useful at the level of actions, although they are highly practical at the level of operations.

- 3. Does the technology available enable the students to engage with that information?** These are represented by the text boxes in the quadrants of Figure 38. These boxes represent the process of organisation: the student will choose the technology and the information and organise them in a way to achieve their learning object. The organisation structured by the students will always be unique. However, the technology has its own intrinsic dynamism, and it also contributes structuring and regulating processes to the organisation. Thus there are two sub-questions to be asked. The first is at the level of actions, such as collaborating, brainstorming, writing, listing, and drawing. The question is does the technology support this type of functionality? The second level is at the level of operations and material conditions. Here it is relevant to ask whether the software allows for mathematical or chemical notation; and whether the student has to draw or write with a mouse, which is difficult, or a keyboard or stylus, which are easier?

The answers to these questions indicate where on the matrix the learning action will lie. If the information that the students need to engage with is a complex concept or process, such as reactions in organic chemistry, or statistical graphing with bivariate data, and there is technology specifically created for the New Zealand secondary curriculum which can support the students in their learning, then these actions can be placed in the green, top right quadrant. These actions are likely to be successful.



If the information is less complex, such as reviewing previously learnt information, then there may also be technology specific to education, if not specific to New Zealand secondary education. For example, Kahoot! provided the functionality for the students to create their own quizzes in Chemistry. These actions can be placed in the green, bottom-right quadrant, and are also likely to be successful.

If the information is less complex, such as looking up definitions, then the technology also does not need to be complex, nor specific for the New Zealand secondary curriculum. These learning actions can be placed in the green, bottom-left quadrant, and are likely to be successful.

The quadrant where the learning actions may not be successful is the top-left quadrant, which is shaded orange. Here the students need to engage with complex concepts and process, with technology that was not designed for this purpose. The technology may enable or may foreclose the learning action. In this thesis there were two vignettes which illustrated where students had difficulties. In the accounting vignette the Excel software foreclosed the learning action as it hid the very processes the students needed to learn. In the English vignette the GoogleDocs software structured collaboration to be “working on the same document at the same time”, not as “sharing the brain” to produce unified and negotiated knowledge. Care must be taking with learning actions in this quadrant.

It is important to remember that all technology in the classroom is subsumed in the wider activity of learning in the classroom. Technology is just one tool that is available to teachers and students in the classroom, albeit a complex, ubiquitous and seductive tool. The accounting students still learned how to complete the financial transactions on paper, and they were happy to do so. The English students completed their task online, and they were happy to do so. But in English the students’ learning action was not the learning action intended by their teacher. There is a myriad of ways that technology can be used in the classroom. This matrix and the

associated questions can support teachers to identify how technology can be used in achieving learning actions.

## 10.4 Research parameters and future directions

This section presents the parameters and limitations of the research design choices made in this thesis. Then possible avenues of future research that are prompted by the research findings are proposed.

### 10.4.1 Parameters of the research

Specific limitations have been addressed throughout this research as part of a reflexive research methodology. However, there are constraints that have circumscribed the study and thus restrict its scope.

Ethics in educational requires that the research does not interfere with the learning of the student. While the microgenetic method was considered there was neither the opportunity in the classroom nor the research capacity to conduct a fully microgenetic study.

The schools and the teachers who participated and offered to conduct the research in their classroom were self-selected. While many teachers stated that they were willing to participate because they were interested in the outcome of the research, it is also possible that some were willing to participate because they perceived that they were examples of best practice of technology in the classroom. It also seemed that the students knew what they were doing and were very confident with a range of technology at a very high level. Younger students who are less familiar with the technology are more likely to be guided by the teacher and have less agency. Given the possibility that these classrooms do represent best practice, combined with the seniority of the students, the high income of the school zones and the BYOD requirements of the schools, it is possible that the ubiquity of the technology is not repeated in schools that serve lower income areas, and issues of equity of access and literacy could take higher precedence in other studies.

### 10.4.2 Areas for future research

The research presented in this thesis opens multiple opportunities for future research.

First, this can contribute to work on the concepts of the extended mind (Clark & Chalmers, 1998) and the cyborg (Clark, 2003). The reconceptualisation in this thesis of the human and tool working together as a functional organ can be considered a cyborg. Whatever the term, the machine-human interface is no longer a hard and fast boundary, and, unlike most conceptualisations of cyborg, with an interpretation using the concept of functional organ the cyborg is not only transformational, but can also reproduce and then disemerge.

Secondly, it has recently been suggested that not only can humans use the IT artefact but IT can use the human artefact (Demetis & Lee, 2017). While Demetis and Lee consider unique systems where the IT uses the human artefact, the conceptualisation this thesis has developed of the functional organ allows that the same activity has different and multiple regulatory loops, ie, it can be an information system where a human uses an IT artefact, *and* an information system where the IT uses the human artefact. For example, Spotify has the obvious use where humans use the information system to listen to music, create lists, and find other lists, while the Bank of England is using Spotify data analytics to gauge the public mood. Here the humans are the data points. In another example, Google Picasa used the human practice of tagging of photos to improve facial recognition software, again providing the data points for the IT.

Thirdly, the discussion on functional organs extends from Leibniz's work of 1660. However, this is the very same work that influenced the Pitt and McCulloch paper *A logical calculus of the ideas immanent in nervous activity* (1943). It is this seminal paper that led to the McCulloch–Pitts (MCP) neuron, which is the basis of neural networks, which forms the backbone of contemporary artificial intelligence. This research rejects the unities and individualities of the machine or human as irrelevant, in favour

of their functions. With AI and the Internet of Things moving the material to the cloud and presenting a functional interface this thesis may provide a conceptualisation of how to understand human interaction with the functions and qualities of these information systems.

Consideration of technology always leads to consideration of possibilities, of the future and of hope. This thesis presents a way of understanding the technology, through its form and function, with a realist understanding of how technology is used. The student, the technology and the information is not an intersection, it is a union. It is a sum of its parts, and it is a changeable swarm of its participants. It is purposeful, but not enduring. In unity of purpose and function, and unison of execution, lies the possibility of learning.

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## Appendix 1 Nuthall's coding used for the information artefact

This Appendix presents Nuthall's coding that was developed over decades of research (Nuthall, 1999, 2001a, 2001b, 2002). The knowledge items are the concepts that the students learn in the classroom. The information items are the items that the students need to learn to understand the knowledge item. These items are presented, followed by examples of the information items from this study.

### A1.1 Knowledge items / concepts

1. Specific propositions: these include facts, names, and descriptions, eg, During the peasant's revolt, the peasants were revolting against very low wages. The heart of New York is called Manhattan.
2. Definitions: these include definitions of technical or other significant words, eg, Refraction means the bending of light. To be short-sighted means that you cannot see things clearly when they are a long way away.

3. Concepts: these involve understanding an idea or general concept and can comprised more than one knowledge item, eg, What did a scribe in ancient Egypt do? What happens when light is refracted?
4. Explanations: these involve identifying how something is or was caused, eg, Why does a piece of white paper look white? Why were the ancient Egyptians almost never involved in wars with their neighbours?
5. Principles and generalisations: these involve propositions of a more general nature that could be deduced from examples, eg, Medieval towns arose from the need of land owners to obtain goods their servants could not produce. In order to measure the air temperature correctly, a thermometer needs to be kept out of direct sunlight. Although there were female pharaohs, women were not considered as important as men in ancient Egypt.
6. Procedures: these items involved getting the students to carry out a procedure or describe how they would carry out a procedure, eg, What is the temperature shown on this [picture of a] thermometer? What do you need to do to produce the colours of the spectrum on the wall of the classroom? What things did they use when they made a mummy in ancient Egypt?

## A1.2 Information items

Information items are that which is needed in order to know or understand the knowledge items, the specific proposition, definition, concept, explanation, principle, generalisation, or procedure.

1. Explicit concept information: The full information (including all key elements) needed to answer the item in words that a student can reasonably be expected to understand.

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- a. Exact information: full information in the words or form (eg picture) used in the item
  - b. Approximate information: Full information but in other words or form, eg paraphrase or different picture
  - c. Wrong or misleading information: Information that appears to be a complete item answer but is wrong or misleading.
2. Implicit or partial information: Information which contains some of the key elements but not all required to answer the item, or information from which the answer to the item can be deduced or inferred.
    - a. Information from which the item answer can be logically deduced.
    - b. Information that contains some, but not all of the key elements needed to answer the item
    - c. Corrections to incorrect information, or information about what the answer is not.
    - d. Implicit word meaning, in which the definition of a word is implicit in the way the word is used or occurs in a discussion or an activity.
    - e. Concept use. The concept is used as part of a description or explanation for another concept or principle in a way that implies the correct meaning for the concept.
  3. Additional and background information, reasons and examples
    - a. Definitions and descriptions of key elements or concepts that make up the information needed to answer the item.
    - b. Reasons or explanations for the proposition, concept, principle, or generalisation being assessed by the item, or,

- use of the concept as the reason or explanation for another concept.
- c. Analogies for key elements or concepts in the information needed to answer the item.
  - d. Descriptions or pictures of examples or instances of the concept, generalisation, or principle being assessed when the defining criteria are made explicit
  - e. Descriptions or pictures of negative examples or non-instances of the concept, generalisation, or principle being assessed, with information that it is not an example or instance
  - f. Personal experiences of students that relate directly to the concept being assessed.
4. Preparatory or contextual information:
- a. Information that provides relevant background, or is related closely to the information needed to answer the item.
  - b. Descriptions or pictures of examples or instances of the concept, generalisation, or principle being assessed when it is not clear why it is an example or instance
  - c. Information about the purpose and procedures of an activity intended to provide item relevant information
  - d. Review of previously presented item-related information or relevant discussion
  - e. Information about events leading up to, or the context of, activities or events, eg, the historical context of an event

- 
- f. Discussion or activities that are intended to prepare for, or lead up to the presentation of relevant information or the carrying out of an item-relevant activity.
  - g. Asking a question, or setting a problem that is designed to elicit or create item-relevant information
5. Mention or reference to key words or concepts. These are references to the names of concepts or principles that do not contain any item-relevant information. They often involve creating links to other concepts or principles but do not add anything to what a student already knows
  6. Activities and procedures. These are activities or procedures that produce, create, or are intended to lead directly to concept-relevant information. This is more than just talking, reading or writing, and includes activities such as carrying out a science experiment or making a model of a key concept.
    - a. Activity or procedure in which the item-relevant information is explicit (obvious) and complete
    - b. Activity or procedure in which the item relevant information is clearly explicit but is only part of the information needed to answer the item.
    - c. Activity or procedure intended to produce concept-relevant information, but the student needs to identify or infer the relevant information. The student may infer part or all of the relevant information.
  7. Instructions for relevant activities.
  8. Visual or object resources. These are resources in which relevant information is available but the resources are not the focus of attention, eg, posters on the wall of the classroom that students

look at from time to time. It is not possible to tell if the student has actually studied the information or not.

- a. Visual or object resources that contain all of the information required to answer the item in an explicit form
- b. Visual or object resources that contain part of the information required to answer the item or contain information from which the answer could be inferred.

### A1.3 Examples of the information items

1. Explicit item of information: information that the student needs to answer the item.
  - a. In School A Year 13 History the students were given the process to evaluate historical documents.
2. Implicit or partial item of information: Some of the information the student needs, but not all of the information.
  - a. In School D Year 13 Chemistry (1) the students were given a diagram of organic compounds and the students had to complete the missing terms, eg, elimination, or the resulting compound after the process.
3. Additional item of information or explanation, reasons and examples of the key concepts.
  - a. In School C Year 12 English the task was to identify literary techniques used in the film *Atonement*; a student asked in physical conflict is a literary technique, and then asked for an explanation of physical conflict from the teacher.
  - b. In School C Year 13 Media Studies the students were making a film, and searched the internet for films which they

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could use as examples of film techniques (eg, point of view, camera work).

4. Preparatory or contextual information that provides relevant background.
  - a. In School B Year 12 History class students were watching interviews (primary sources) in a documentary. The students asked when the documentary was made. The teacher asked, “Anyone got Google up?” A student found the documentary was made in 1989.
5. Mention or reference to key words or concepts.
  - a. In School C Year 12 English class two students seek definitions:
    - i. Student<sub>2</sub> asks Student<sub>1</sub> for definition of repenting.
    - ii. Student<sub>5</sub> googles for definition of cowardice, then searches an online thesaurus.
  - b. In School D Year 13 English the teacher asks the students to look up a word and suggests the dictionaries. All the students use their devices.
6. Activities and procedures that produce, create, or are intended to lead directly to concept-relevant information.
  - a. In School C Year 13 Statistics students were given activity to draft outline of their assignment; they were to do it on A3 sheets of paper not on laptops.
7. Instructions for relevant activities.
  - a. In School C Year 13 Statistics students were given activity to draft outline of their assignment; they were to do it on A3

sheets of paper not on laptops. They were allowed to access the unit booklet.

8. Visual or object resources in which relevant information is available but the resources are not the focus of attention.
  - a. In School B Year 12 History class students were studying the My Lai massacre and suggested wider reading was watching *Full Metal Jacket* for basic training, and *Band of Brothers*.



## Appendix 2 The data collection instruments

This appendix presents two data collection instruments, the teacher interview checklist and the final student questionnaire.

### A2.1 Teacher interview checklist

1. What is the objective of this class? For example, is there a specific unit or part of unit being taught? Why is this activity taking place?
2. What tools do you expect the students to use to perform this activity? For example, will the students be expected to use texts, the internet or other tools?
  - a. If yes, what tools are being used, what is the purpose of the tools?
3. Are there any rules or regulations that affect your or the students' ability to perform this activity?

4. How are the students expected to perform this activity on their own, with assistance from you, with assistance from their peers, or a combination of these?
  
5. Do you or the students perform this activity in the context of the wider community?
  
6. What is the desired outcome of this activity? For example, do you expect the students to acquire a new skill or insight, complete a school task, identify information needs, or pass the subject?

## A2.2 Student questionnaire final version

I am conducting research on how students use the internet in learning. I would greatly appreciate your completing this questionnaire; it may take up to 10 minutes of your time. Please answer every question as well as you can. Because only a small number of people are being surveyed your response is very important to me. Your answers will, of course, be strictly confidential.

Thank you in advance for your time and effort.

1. In this class that has just finished did you have a device that can access the internet?

a. Yes

b. No

2. In a perfect world which device(s) *would you use* to access the internet? You may tick more than one box.

a. Smartphone

b. Smartwatch

c. Desktop

d. Laptop

e. Tablet

f. Microsoft HoloLens

g. Other (please specify)

3. In this class, which device(s) *did you actually use* to access the internet? Please tick *all* devices that you used.

Own School's

a. Smartphone

b. Smartwatch

c. Desktop

d. Laptop

e. Tablet

f. Microsoft HoloLens

g. Other (please specify)

4. In this class that has just finished what did you go online to do? You may tick more than one box

a. To take notes

b. To read information that my teacher has collected

- |    |  |                          |
|----|--|--------------------------|
| c. | To develop a plan for written work   | <input type="checkbox"/> |
| d. | To write up my work  | <input type="checkbox"/> |
| e. | To manage my school work through the school learning management system                           | <input type="checkbox"/> |
| f. | To manage my school work through other applications, eg, Dropbox, OneNote or email               | <input type="checkbox"/> |
| g. | To access social networks, eg, Facebook or Twitter   | <input type="checkbox"/> |
| h. | To access a web browser, eg, IE or Firefox   | <input type="checkbox"/> |
| i. | To access a translation application, eg, through Baidu   | <input type="checkbox"/> |
| j. | To find information by searching for it, eg, Google, Google Scholar, Wolfram Alpha               | <input type="checkbox"/> |
| k. | To find information through an online encyclopedia, eg, Wikipedia                                | <input type="checkbox"/> |
| l. | To find information in a specialist website, eg, National Library, ERIC, YouTube                 | <input type="checkbox"/> |
| m. | To use a specialist application, eg, a specialist maths site                                     | <input type="checkbox"/> |
| n. | To complete work in another subject  | <input type="checkbox"/> |
| o. | To complete work in this subject, but for an advanced assessment not covered in this class today | <input type="checkbox"/> |
| p. | Other (please specify)   |                          |

5. Did the application help you to achieve your desired outcomes? Some possible outcomes are (tick as many as are relevant):

- |    |   |                          |
|----|---|--------------------------|
| a. | To manage my school work                      | <input type="checkbox"/> |
| b. | To find new information                       | <input type="checkbox"/> |
| c. | To get background information                 | <input type="checkbox"/> |
| d. | To clarify already known information          | <input type="checkbox"/> |
| e. | To translate a word / some words              | <input type="checkbox"/> |
| f. | To define a word / some words                 | <input type="checkbox"/> |
| g. | To contact a friend for class related reasons | <input type="checkbox"/> |

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- h. To contact a friend for non-class related reasons
- i. Other (please specify)

6. If the application did not help you to achieve your desired outcomes, what is your next step?

7. Did the application help you to achieve your objectives? Some possible objectives are (tick as many as are relevant):

- a. To do enough to answer the teacher's questions
- b. To do well and gain personal satisfaction with my work
- c. To do as well or better than my classmates
- d. To have a solid education to get a well-paid or secure job
- e. To learn, as there is enjoyment in learning
- f. To be at the top of the class
- g. Other (please specify)

8. Generally, for the most used application or website in this class, did you use it because:

- a. You thought of using it
- b. The teacher required you to use it
- c. The teacher suggested you use it
- d. Another student suggested using it or was using it
- e. Another reason, eg, another person or website directed you to it (please specify)

9. Was there any problem accessing the applications? Eg were some blocked, was there technical difficulty in accessing the applications, was the screen too small, or did the device have inadequate software?

10. Generally, for the most used application or website in this class:

a. Did you work alone?

b. Did you work in a pair?

c. Did you work in a group?

d. Did you work supervised by your teacher?

11. When using the application do you prefer to use it in a group, alone, or in pairs?

12. Given the choice, and generally speaking, would you prefer to do the following electronically or on paper?

	Electronically	It depends	On paper
a. Take notes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Read information that my teacher has collected	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Develop my plan for written work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Write up my work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

13. In your opinion, does going online help you in your learning? Why?

14. Name:

15. Class:

16. Date:

Thank you for your time and consideration: your contribution to this research is greatly appreciated.

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## Appendix 3 The cases and education in New Zealand

Primary and secondary schools are the second level of education in New Zealand. Education is free for New Zealand and New Zealand residents aged between 5 and 19 at Government owned and funded *State schools* (Ministry of Education, 2018a), although schools are able to charge fees for non-core activities and ask for donations. School is compulsory from age 6 to 16. The year levels are called Year 1 to Year 13. All of the students in the study were over 16; nine of the classes were Year 13, two of the classes were Year 12.

Most schools in New Zealand are *State schools*. They teach the national curriculum, which includes the NCEA standards, see below, and are non-religious. *State-integrated schools* are schools with a special character, often being affiliated with a religion. They are funded by the Government and teach the national curriculum. *Private schools* are mostly funded through school fees and do not have to follow the national curriculum. All the classes in the study were following the national curriculum (Ministry of Education, 2018a).

In the national curriculum senior students work towards the *National Certificate of Educational Achievement (NCEA)*. The students' skills and knowledge are assessed against a standard, which could be internally marked by the teacher, or externally marked at the end of year after national examinations. Students will gain credits when achieve a standard.

In 2015 52% of school leavers left with qualifications at Year 13, and 60% of all school leavers had enrolled in tertiary education. In the schools in this study most of the students who attempted NCEA achieved it. One school had an achievement rate of between 80 and 85%, the other three schools had an achievement rate of between 95 and 100% (NZQA, 2018).

A summary of the cases is presented below.



<b>School</b>	<b>Characteristics</b>	<b>Broadband</b>	<b>Class</b>	<b>Total number of students</b>	<b>Number of consenting students</b>	<b>Number who completed questionnaire (online)</b>	<b>Percentage of consenting students who completed the questionnaire</b>	<b>Number of lessons observed</b>
School A	Urban	Fibre	Year 13 History	24	24	24	100	12
	Private	Not UFB	Year 13 Accounting	13	13	13	100	9
School B	Regional	Fibre	Year 13 History	22	21	14	66	5
		Not UFB	Year 12 History	15	15	15	100	5
	State		Year 13 Statistics	29	27	14	52	6
School C	Urban	No fibre	Year 13 Media studies	15	13	10 (10)	87	5
	Private	Cable	Year 12 English	22	21	17 (4)	81	5
			Year 13 Statistics	16	16	9 (9)	56	6
School D	Urban	Fibre	Year 13 English	9	9	9 (0)	100	5
	State integrated	UFB	Year 13 Chemistry (1)	13	13	10 (0)	77	4
			Year 13 Chemistry (5)	13	13	11 (0)	85	5
total			11	191	185	145 (23)		67
average				17				6
percentage					97 <sup>22</sup>	78 (12) <sup>23</sup>		

Table 10: Summary of the cases.

<sup>22</sup> Percentage = consenting students / number of students

<sup>23</sup> Percentage = students who completed the questionnaire / consenting students

### A3.1 School A

This is an urban, Private school. The school IT personnel advised that they had fibre to the hub (ie, on the street), and had installed fibre to the main computer and fibre to the wireless router. The students had access to unlimited broadband with download speeds of 1000Mbps. All students had a laptop or tablet in class. This school was observed in 2015.

#### A3.1.1 Year 13 History

Between 4 June and 19 June, twelve lessons were observed. There were 24 students in the class in all of them consented to participate and 23 completed the questionnaire. The students were studying towards the [NCEA Standard 91437](#): analyse different perspectives of a contested event of significance to New Zealanders. This is an internal assessment. In this class the contested event was the [Northern War](#), from 1845 to 1846. The key learning of the students was to learn how to evaluate and compare historical documents (NZQA, 2012b).

#### A3.1.2 Year 13 Accounting

Nine classes were observed between 25 May and 10 June. There were 13 students, all participated and all completed the questionnaire. The students were studying the second part of the [NCEA Standard 91406](#): demonstrate understanding of company financial statement preparation, and working towards an external exam at the end of the year. The key learning was to learn the processes to prepare company financial statements (NZQA, 2012a).

### A3.2 School B

This is a regional, public school. The school has fibre to the hub, and has installed fibre to the main computer and fibre to the wireless router through the Ministry of Education wireless SNUP<sup>24</sup> and Ruckus hardware. The students have access to unlimited broadband with download speeds of 600Mbps. The library and some classrooms have desktop computers, but

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<sup>24</sup> The School Network Upgrade Project (SNUP) upgrades the data and electrical internal networks in state and state-integrated schools to make them ready for the ultra-fast broadband. The Ministry of Education funds the majority of the costs with schools contributing, and then manages the project (Ministry of Education, 2011a, 2016b).

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they are acknowledged to be of poor quality (in observations 1 desktop in the library took 3 minutes to boot up; 1 desktop in a classroom took 8 minutes, before the student moved to another desktop). The library also has 37 chromebooks which the students can borrow: these are usually all taken before the first period. The chromebooks are not able to be booked. This and the following schools were observed in 2017.

### A3.2.1 Year 13 History

The first case study was of a year 13 history class. There were 22 students; 21 consented to participate in the research; 14 completed the questionnaire. Between 31 March and 7 April, five lessons were observed. The students were studying towards the [NCEA Standard 91437](#): analyse different perspectives of a contested event of significance to New Zealanders. This is an internal assessment worth 5 credits. In this class the students could choose any event from a topic entitled “the US century”. Some events being studied by the students were the dropping of the atomic bomb on Hiroshima, the torture and prison abuse in Abu Ghraib, and the War in Afghanistan. The key learning of the students was to learn how to evaluate and compare historical documents (NZQA, 2012b).

### A3.2.2 Year 12 History

The second case study was a year 12 history class. There were 15 students; 15 consented to participate in the research; 15 completed the questionnaire. Between 31 March and 7 April, five lessons were observed. The students were studying towards the [NCEA Standard 91232](#): interpret different perspectives of people in an historical event that is of significance to New Zealanders (NZQA, 2014). This is an internal assessment worth 5 credits. The historical event is the My Lai Massacre. Again, the key learning of the students was to learn how to evaluate and compare historical documents.

### A3.2.3 Year 13 Statistics

The third case study was a year 13 statistics class; six classes were observed between 29 March and 6 April. There were 29 students; 27 consented to participate in the research; 14 completed the questionnaire. The students were studying the [NCEA Standard 91581](#): Investigate bivariate measurement data; and some were moving on to [NCEA Standard 91582](#): Use statistical methods to make a formal inference. Both are internal assessments worth 4

credits each. The key learning was to learn to use statistical tools to investigate bivariate measurement data, and use statistical tools to make a formal inference (NZQA, 2016, 2017e).

### A3.3 School C

The case studies were conducted in an urban, Private school. The school is not on fibre, but does use fibre to the Wifi access ports. The students have access to broadband with download speeds of 100Mbps. Classrooms each have a desktop computer. The library has 20 iPads, 25 chromebooks and 20 laptops which the students can borrow.

#### A3.3.1 Year 13 Media studies

The first case study was of a year 13 Media studies class. There were 15 students; 13 consented to participate in the research; 10 completed the questionnaire online. Between 17 May and 24 May, five lessons were observed. The students were studying towards the [NCEA Standard 91494](#): produce a design for a media product that meets the requirements of a brief. This is an internal assessment worth 4 credits. In this class the students could choose any subject for their brief. Some subjects being studied by the students were ethical fashion, faith, loyalty to Wellington. To achieve the standard students need to “Produce a design involves completing concept, treatment, and pre-production activities that demonstrate design choices that meet the requirements of a brief and show evidence of reflection and/or refinement” (NZQA, 2017d).

#### A3.3.2 Year 12 English

The second case study was a year 12 English class. There were 22 students; 21 consented to participate in the research; 13 completed the questionnaire online, 4 completed the questionnaire on paper. Between 17 May and 24 May five lessons were observed. The students were studying towards the [NCEA Standard 91099](#): analyse specified aspect(s) of studied visual or oral text(s), supported by evidence. This is an external assessment worth 4 credits. To achieve the standard students need to “Analyse specified aspect(s) of studied visual or oral text(s) involves exploring and interpreting how meanings and effects are created in the text(s) and discussing specified aspects of these text(s)” (NZQA, 2017a).

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### A3.3.3 Year 13 Statistics

The third case study was a year 13 Statistics class. There were 16 students; all consented to participate in the research, and 9 completed the questionnaire online. Between 21 June and 28 June six lessons were observed. The students were studying towards the [NCEA Standard 91581](#): Investigate bivariate measurement data. This is an internal assessment worth 4 credits. To achieve the standard the students need to showing evidence of using each component of the statistical enquiry cycle: using existing data sets; finding, using, and assessing appropriate models (including linear regression for bivariate data), seeking explanations, and making predictions; using informed contextual knowledge and statistical inference; and communicating findings and evaluating all stages of the cycle (NZQA, 2017e).

### A3.4 School D

The case studies were conducted in an urban, State-integrated school. This school was the only one connected to the Ultra-Fast Broadband fibre initiative. Each teacher has a laptop which is carried between classes. There are 17 desktops available in the library, as well as 27 iPads and 25 chromebooks which can be booked as a class set or individually. There is a computer lab in the library which has 29 desktops and which can be booked for a class. This school does not require BYOD in the senior classes.

#### A3.4.1 Year 13 English

The first case study was a year 13 English class. There were 9 students; 9 consented to participate in the research; all completed the questionnaire. Between 7 June and 17 June five lessons were observed. The students were studying towards the [NCEA Standard 91478](#): Respond critically to significant connections across texts, supported by evidence. This is an internal assessment worth 4 credits. In this class the students were examining the dystopian genre using the films *Mad Max*, *District 9* and *Children of Men*, and a fourth text that they were free to choose. To achieve the standard students need to “Respond critically to significant connections across texts, supported by evidence” which involves “making evaluative interpretations and judgements” (NZQA, 2017c).

#### A3.4.2 Year 13 Chemistry (1)

The second case study was a year 13 Chemistry class. There were 13 students; all consented to participate in the research, and 10 completed the questionnaire. Between 7 June and 17 June 4 lessons were observed. The students were studying towards the [NCEA Standard 91391](#): Demonstrate understanding of the properties of organic compounds. The students work towards an external assessment worth 5 credits. To achieve the standard students need to “Demonstrate understanding of the properties of organic compounds”, which involves “involves naming using IUPAC conventions (no more than eight carbons in the longest chain) and/or drawing structural formulae of organic compounds and giving an account of their physical properties and/or reactivity. This requires the use of chemistry vocabulary, symbols, and conventions” (NZQA, 2017b).

#### A3.4.3 Year 13 Chemistry (5)

The third case study was a year 13 Chemistry class. There were 13 students, and all consented to participate in the research, 11 completed the questionnaire. Between 7 June and 17 June five lessons were observed. The students were also studying towards the [NCEA Standard 91391](#): Demonstrate understanding of the properties of organic compounds.

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## Appendix 4 Ethics documentation

## A4.1 SIM HEC Application

**SIM HUMAN ETHICS COMMITTEE****Application for Approval of Research Projects**

Please email applications to your supervisor, who will then email it to a SIM HEC member for a preliminary review.

**Note:** The Human Ethics Committee attempts to have all applications approved within 6 working days, but a longer period may be necessary if applications require substantial revision.

**Thank you for your comments and for the opportunity to improve my application. I have dealt with the issues you raised within the body of the application form and marked them in red, but have taken the opportunity to respond to your additional comments at the beginning of the form.**

**Additional Comments** (dealing with non-ethical issues only)

The project title, *Capturing information technology use by secondary school students in New Zealand*, is a nod to the seminal paper by DeSanctis and Poole (1994) *Capturing the complexity in advanced technology use: adaptive structuration theory*. A key observation of DeSanctis and Poole is, at page 122,

Many researchers believe that the effects of advanced technologies are less a function of the technologies themselves than of how they are used by people. For this reason, actual behavior in the context of advanced technologies frequently differs from the "intended" impacts (Kiesler 1986, Markus and Robey 1988, Siegel, Dubrovsky, Kiesler and McGuire 1986). People adapt systems to their particular work needs, or they resist them or fail to use them at all; and there are wide variances in the patterns of computer use and, consequently, their effects on decision making and other outcomes. We propose adaptive structuration theory (AST) as a framework for studying variations in organization change that occur as advanced technologies are used. The central concepts of AST, structuration (Bourdieu 1978, Giddens 1979) and appropriation (Ollman 1971), provide a dynamic picture of the process by which people incorporate advanced technologies into their work practices. [Emphasis mine.]

The literature reviews indicate that examining information technology in schools as a dynamic process could be productive. There are a number of theories that could be used for a dynamic analysis, adaptive structuration theory is only one of them. Lanzara (2010) examines the introduction of video cameras in Italian courts with practice theory. Both of these theories stress the importance of human activity and the dynamic processes of using technology.<sup>1</sup> A third theory which provides a dynamic lens with which to view technology in human activity, and

<sup>1</sup> "Consistent with structuration theory, AST focuses on social structures, rules and resources provided by technologies and institutions as the basis for human activity." (DeSanctis & Poole, 1994, p. 125) and "The findings of the study provide fresh insights into the problems encountered and the strategies enacted by practitioners as they strive to integrate new tools and media within a long-established activity system." (Lanzara, 2010, p. 1370)



which I think is appropriate to analyse the use of information technology in schools, is activity theory.

The purpose of schools is to teach, and the purpose of students is to learn. Because I am looking at technology in the hands of the students, not the administrators nor the teachers, I am necessarily asking, how is this technology affecting the learning of the students? I am not the first to ask this question (Belo, Ferreira, & Telang, 2011; Istance & Kools, 2013; Ito et al., 2013; U.S. Department of Education Office of Planning Evaluation and Policy Development, 2010). To contribute original knowledge I am approaching data collection and analysis from two under-researched perspectives. First, I am studying technology in schools from the perspective of the student (Facer, 2012). Secondly, I am using activity theory to collect and analyse the data.

According to Burton-Jones, McLean and Monod (2014) two key building blocks of theory are concepts and relationships. Three core concepts within activity theory that were developed by Vygotsky in the 1920s, and which have continued to be important in all derivations of activity theory developed over the last 90 years, are first, that human activity is directed towards a material or ideal object or outcome. Secondly, while elementary behaviour can be a direct response to a stimulus, human activity that results in higher psychological processes, such as memory and learning, are complex acts, mediated by sign systems or tool systems (including information systems). And thirdly, that human activity is socially, culturally and historically constituted. A tool that I am using to delineate the relationship between these concepts is Engeström's third generation activity theory (2010; 2000, 2001). In order to use activity theory comprehensively then all these concepts and relationships must be accounted for in the data collection, and I am using Mwanza's Activity-Oriented Design Methods (2002; 2011) as a tool for data collection that draws out all these aspects.

So, the title for the project asks, how do we capture complex information technology use? Following DeSanctis and Poole, we look at the dynamic process of how people incorporate advanced technologies into the work practices, or in this case, into their school practices. One way to analyse this dynamic process is by using activity theory, which requires the researcher to scrutinize human activity by which information technology mediates learning in its social, cultural and historical setting, with the many tools that have been developed in activity theory. This research finds resonance in Yoo's (2010, p. 215) call to research experiential computing, which he defines as, "digitally mediated embodied experiences in everyday activities through everyday artifacts with embedded computing capabilities."

Belo, R., Ferreira, P., & Telang, R. (2011). *The effects of broadband in schools: evidence from Portugal* (pp. 1–43). Retrieved from <http://ssrn.com/abstract=1636584>

Burton-Jones, A., McLean, E. R., & Monod, E. (2014). Theoretical perspectives in IS research: from variance and process to conceptual latitude and conceptual fit. *European Journal of Information Systems*, (00), 1–16. doi:10.1057/ejls.2014.31

DeSanctis, G., & Poole, M. S. (1994). Capturing the complexity in advanced technology use: adaptive structuration theory. *Organization Science*, 5(2), 121–147.

Engeström, Y. (2000). Activity theory as a framework for analyzing and redesigning work. *Ergonomics*, 43(7), 960–974. doi:10.1080/001401300409143

- Engeström, Y. (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of Education and Work, 14*(1), 133–156. doi:10.1080/13639080020028747
- Engeström, Y., & Sannino, A. (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review, 5*(1), 1–24. doi:10.1016/j.edurev.2009.12.002
- Facer, K. (2012). Taking the 21st century seriously: young people, education and socio-technical futures. *Oxford Review of Education, 38*(1), 97–113.
- Istance, D., & Kools, M. (2013). OECD Work on Technology and Education: innovative learning environments as an integrating framework. *European Journal of Education, 48*(1), 43–57. doi:10.1111/ejed.12017
- Ito, M., Gutiérrez, K., Livingstone, S., Penuel, B., Rhodes, J., Salen, K., ... Watkins, S. C. (2013). *Connected learning: an agenda for research and design*. Irvine, CA. Retrieved from [www.dmlhub.net/publications](http://www.dmlhub.net/publications)
- Lanzara, G. F. (2010). Reshaping practice across media: material mediation, medium specificity and practical knowledge in judicial work. *Organization Studies, 30*(12), 1369–1390. doi:10.1177/0170840609349873
- Mwanza, D. (2002). *Towards an activity-oriented design method for HCI research and practice*. The Open University.
- Mwanza-Simwami, D. (2011). AODM as a framework and model for characterising learner experiences with technology. *Journal of E-Learning and Knowledge Society, 7*(3), 75–85.
- U.S. Department of Education Office of Planning Evaluation and Policy Development. (2010). *Evaluation of evidence-based practices in online learning: a meta-analysis and review of online learning studies*. Washington, DC. Retrieved from [www.ed.gov/about/offices/list/oepd/ppss/reports.html](http://www.ed.gov/about/offices/list/oepd/ppss/reports.html)
- Yoo, Y. (2010). Computing in everyday life: a call for research on experiential computing. *MIS Quarterly, 34*(2), 213–231.

**1 NATURE OF PROPOSED RESEARCH:**

(a) Student Research (delete one)

(b) If Student Research Degree **PhD** Course Code **INFO 690**

(c) Project Title: **Capturing information technology use by secondary school students in New Zealand**

**2 INVESTIGATORS:**

(a) Principal Investigator

Name **Lauren Bennett**

e-mail address **lauren.bennett@vuw.ac.nz**

School/Dept/Group **School of Information Management**

(b) Other Researchers	Name	Position
	<b>None</b>	.....
		.....

(c) Supervisor (in the case of student research projects)

**Janet Toland, Programme Director, School of Information Management**

**Bronwyn Howell, School of Management**

*Your supervisor has seen and approved the submission of this application* **Y**

**3 DURATION OF RESEARCH**

(a) Proposed starting date for data collection – After HEC approval has been granted.  
(Note: that NO part of the research requiring ethical approval may commence prior to approval being given)

(b) Proposed date of completion of project as a whole: June 2016

**4 PROPOSED SOURCE/S OF FUNDING AND OTHER ETHICAL CONSIDERATIONS**

(a) Sources of funding for the project  
Please indicate any ethical issues or conflicts of interest that may arise because of sources of funding e.g. restrictions on publication of results

**Self funded**

(b) Is any professional code of ethics to be followed **N**  
If yes, name .....

(c) Is ethical approval required from any other body **N**  
If yes, name and indicate when/if approval will be given  
.....

## 5 DETAILS OF PROJECT

Briefly Outline:

(a) The objectives of the project

**The objectives are:**

- (a) to identify the fast fibre enabled technologies that are used by students in New Zealand secondary schools;
- (b) to explore fast fibre enabled technologies in the social, cultural, political and historical context of teaching and learning in New Zealand secondary schools;
- (c) to investigate how students are using fast fibre enabled technologies in learning; and
- (d) to provide an activity theory informed study on how fast fibre enabled technology (the tool) mediates the learning (the activity) of secondary school students (the subject) (together comprising the activity system).

(b) Method of data collection

To achieve the objectives of the project I have chosen the case study research method, an intensive examination of events occurring in a single structure, or a few structures, over a period of time. Case study is appropriate to answer the question, is suitable for both activity theory<sup>2</sup> and critical realism<sup>3</sup>, and has been suggested by a respected researcher in the field<sup>4</sup>. In the first instance I am seeking approval for a pilot case study in a single school in two classes (ideally one that provides literacy credits and in that provides numeracy credits) over the period of two weeks or a *standard* (what a student needs to know or needs to achieve to gain credits towards New Zealand national qualifications<sup>5</sup>). A school has already consented to assist me in my research, and my data collection is necessary delimited by the school in two ways. First, there is the ethical requirement not to interfere in students' learning, and while I have my ideal research design it will in reality be affected by what the school is willing to provide. Secondly, there is the technical delimitation, in that what I can capture through the computer logs is defined by what software the schools use. Once this pilot study has

<sup>2</sup> Shanahan, M.-C. (2010). Activity Theory. In *Encyclopedia of Case Study Research*. SAGE Publications, Inc. doi:<http://dx.doi.org/10.4135/9781412957397.n3>.

<sup>3</sup> Wynn, D., & Williams, C. K. (2012). Principles for conducting critical realist case study research in information systems. *MIS Quarterly*, 36(3), 787–810.

<sup>4</sup> Andrew Burton-Jones (2014) Private conversation.

<sup>5</sup> Standards (nd) <http://www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/understanding-ncea/how-ncea-works/standards/>.

been completed I will be in a better position to identify what further schools and classes would be productively studied.

Once consent has been gained from the students there will be 5 methods of data collection:

Observation. I will observe the students in the classroom during class, generally about 50 minutes long. I will take notes during the observation.

Interview. I will interview the teacher before the class to identify the motives and objectives of the teacher to be achieved in the class.

Questionnaires. I will provide short questionnaires to the students after the class asking them to evaluate their use of fast-fibre technologies in the class. The questionnaire should take less than 10 minutes. I anticipate that the questionnaire will be administered once during the standard, and once at the end of the standard.

Discussion. If any of the students wish to discuss the project during or after the completion of the questionnaire I would like to use any information gathered then also.

Computer logs. If the class takes place in a computer lab, or if the students have to use a log in to access the internet or school intranet I will take computer logs of the class through web-logs or server-logs. Depending on the software used by the schools the computer logs may capture data from each student through the school learning management system ("LMS"), eg Blackboard or Moodle. An LMS may be capable of collecting collect and reporting student actions, such as which web pages a student visits, interactions and testing data, enabling me to build representations of online students' activity that can support self-reported responses through the questionnaires.

(c) The benefits and scientific value of the project

This study will contribute to:

- (a) The theoretical understanding of use in information systems. This study will propose a nuanced and responsive conceptualisation of the use of information technology artefacts in education. This will contribute to the information systems discipline, in the subfield of IS development and use.
- (b) The practical application of understanding how technology is used in the classroom through context-driven, socially embedded qualitative methods, and through responding to the rapidly changing environment by studying internet applications.

(d) Characteristics of the participants

The participants are year 12 and 13 secondary school students aged between 16 and 18. I will run a pilot project through a school that I have previously worked at. In senior classrooms it is very rare that a class will be told to sit at a computer and told to work with certain software to achieve a certain result. This happens in junior classrooms

where the teacher says, for example, use GoVocab to learn german vocabulary<sup>6</sup>, or use PowerPoint to present your project. Senior classrooms are different in two key respects. First, in the pilot school, senior students generally use their own laptops and smartphones in every class. Schools in New Zealand are widely implementing BYOD policies, and so more students will soon have access to the internet all the time. That means that access will really be ubiquitous and become part of everyday activities. Secondly, in senior classrooms the teacher will define objectives for the student, and let the student work out for him or herself how to achieve the objective. For example, in one history class in which I was present, all the students had laptops and smartphones. After the teacher's lecture the teacher asked the students to find a photo that represented to them what they had learned in this class. The students used their laptops to search for photos. This required the students to analyse and synthesize the lecture, to change from verbal to visual text, another form of synthesis, and to apply their learning to achieve a result. This is a really good example of how using technology can result in positive learning.

The main characteristic of the class used for data collection is that it comprises senior students, who have the latitude as described above. A secondary characteristic is that I would like to study two classes, one that provides numeracy credits and one provides literacy credits. I hypothesise that any difference between the classes may be due to the affordances of the software rather than the fast-fibre technology.

The research design has been modified to include a parental consent form for those students under 16.

(e) Method of recruitment

I have been given permission to run a pilot through a school that I have previously worked at by the headmaster. I have also discussed with a history teacher and a science teacher about observing their class, and verbal permission has been given, although this will need to be confirmed with the headmaster and the teachers.

From that pilot I will assess further characteristics of participants for the in-depth study.

.....  
(f) Payments that are to be made/expenses to be reimbursed to participants

**None**

(g) Other assistance (e.g. meals, transport) that is to be given to participants

I anticipate that the questionnaires will be completed and discussions engaged in during recess or lunchtime. Providing fruit or bars may assuage both the students' hunger and their desire to leave immediately.

.....  
<sup>6</sup> govocab.com

(h) Any special hazards and/or inconvenience (including deception) that participants will encounter

With research in education there is always the concern that the research will take time from regular teaching and learning activities. This needs to be kept to a minimum to ensure that the students' educational progress are not hindered. This will be limited by making observations during scheduled class time, keeping the questionnaire short, and by having any overrun of time flow into recess or lunch.

(i) State whether consent is for: (Please indicate as many as it applies)

- |   |   |
|---|---|
| (i) the collection of data                        | Y |
| (ii) attribution of opinions or information       | N |
| (iii) release of data to others                   | N |
| (iv) use for a conference report or a publication | Y |
| (v) use for some particular purpose (specify)     | Y |

**The consent is for the collection of data which will be used as the basis for my PhD.**

Attach a copy of any questionnaire or interview schedule to the application

(j) How is informed consent to be obtained

**Consent needs to be obtained from the principal, the participating teachers, the students, and the guardians of any student under 16. At any time any participant can withdraw consent. If a student or the guardians of a student under 16 do not consent or withdraw their consent then that has certain ramifications for the project, which have been considered. First, the research is designed as confidential not anonymous so that any participation can be traced and removed. Confidential questionnaires and computer logs will not be collected or can be removed and destroyed. A particular difficulty arises because the study involves observing a class that the student cannot withdraw from. This has been considered, and is mitigated in two ways. First, senior classes are quite small. In the pilot school the year 13 history class in 2014 had about 12 students. Discussions with a history teacher indicated that senior classes are quite small in many schools: this means that non-participating students are identifiable during their class, and can be excluded from the study. Secondly, the observations will not be videoed or taped, only notes will be taken. These factors give comfort that data will not be collected from the non-participating student.**

- (i) the research is strictly anonymous, an information sheet is supplied and informed consent is implied by voluntary participation in filling out a questionnaire for example (include a copy of the information sheet)

N



- (ii) the research is not anonymous but is confidential and informed consent will be obtained through a signed consent form (include a copy of the consent form and information sheet) **Y**
- (iii) the research is neither anonymous nor confidential and informed consent will be obtained through a signed consent form (include a copy of the consent form and information sheet) **N**
- (iv) informed consent will be obtained by some other method (please specify and provide details) **N**

**The data collected from the questionnaires and the computer logs will not be anonymous but they will be confidential. I intend to match the questionnaires and computer logs to compare self-reported and actual usage. Only myself and my supervisor will have access to the data and all opinions and data will be reported in aggregated form in such a way that individual persons and organisations are not identifiable.**

With the exception of anonymous research as in (i), if it is proposed that written consent will not be obtained, please explain why

.....

.....

.....

(k) If the research will not be conducted on a strictly anonymous basis state how issues of confidentiality of participants are to be ensured if this is intended (e.g. who will listen to tapes, see questionnaires or have access to data). Please ensure that you distinguish clearly between anonymity and confidentiality. Indicate which of these are applicable.

- (i) access to the research data will be restricted to the investigator **N**
- (ii) access to the research data will be restricted to the investigator and their supervisor (student research) **Y**
- (iii) all opinions and data will be reported in aggregated form in such a way that individual persons or organisations are not identifiable **Y**
- (iv) Other (please specify)

.....

.....

.....

(l) Procedure for the storage of, access to and disposal of data, both during and at the conclusion of the research. Indicate which are applicable:



- (i) all written material (questionnaires, interview notes, etc) will be kept in a locked file and access is restricted to the investigator **Y**
- (ii) all electronic information will be kept in a password-protected file and access will be restricted to the investigator **Y**
- (iii) all questionnaires, interview notes and similar materials will be destroyed:
  - (a) at the conclusion of the research **N**
  - or** (b) five years after the conclusion of the research **Y**
- (iv) any audio or video recordings will be returned to participants and/or electronically wiped **Y**
- (v) other procedures (please specify):

.....  
 .....

If data and material are not to be destroyed please indicate why and the procedures envisaged for ongoing storage and security

.....  
 .....

(m) Feedback procedures You should indicate whether feedback will be provided to participants and in what form. If feedback will not be given, indicate the reasons why.

**A summary of the results will be emailed to the participating schools, to the principal and the participating class teachers. Participating students may elect to receive a summary of the results by providing an email address.**

.....  
 .....

(n) Reporting and publication of results. Please indicate which of the following are appropriate. The proposed form of publications should be indicated on the information sheet and/or consent form.

- (i) publication in academic or professional journals **Y**
- (ii) dissemination at academic or professional conferences **Y**
- (iii) deposit of the research paper or thesis in the University Library (student research) **Y**
- (iv) a case study used for teaching purposes **N**
- (v) other (please specify)

.....  
 .....

Signature of investigators as listed on page 1 (including supervisors) and Chair of SIM HEC.

**NB: All investigators and the Chair of SIM HEC must sign the form, then send it to the SIM HEC administrator for filing once the electronic application has been approved.**

..... Date.....

..... Date.....

..... Date.....

**Supervisors:**

..... Date.....

..... Date.....

**Chair of SIM HEC:**

..... Date .....

## APPLICATIONS FOR HUMAN ETHICS APPROVAL

### CHECKLIST

- Have you read the Human Ethics Committee Policy?
  - Have you read the Faculty of Commerce and Administration's HEC Guide?
  - Is ethical approval required for your project?
  - Have you established whether informed consent needs to be obtained for your project?
  - In the case of student projects, have you consulted your supervisor about any human ethics implications of your research?
  - Have you included an information sheet for participants which explains the nature and purpose of your research, the proposed use of the material collected, who will have access to it, whether the data will be kept confidential to you, how anonymity or confidentiality is to be guaranteed?
  - Have you included a written consent form?
  - If not, have you explained on the application form why you do not need to get written consent?
- Are you asking participants to give consent to:
- collect data from them
  - attribute information to them
  - release that information to others
  - use the data for particular purposes
- Have you indicated clearly to participants on the information sheet and/or consent form how they will be able to get feedback on the research from you (e.g. they may tick a box on the consent form indicating that they would like to be sent a summary), and how the data will be stored or disposed of at the conclusion of the research?
  - Have you included a copy of any questionnaire or interview checklist you propose using?

### POINTERS TO AVOID HAVING APPLICATIONS RETURNED BEFORE HEC REVIEW

- ▶ The approval process is speeded up by not requiring the hard copy of your application form with the signatures on it at the initial review process. The complete application (HEC application form, info sheet, consent form, covering letter, questionnaire etc.) is to be emailed as an attachment in one file to your supervisor who will email it to an SIM HEC member for a preliminary review.
- ▶ Do not insert a date into item 3 a.
- ▶ Delete the "Y" or "N" option that is not required. **DO NOT** remove any other text from the application form.
- ▶ **BOLD** your answers if you wish but do not alter the font anywhere else in the form.

## A4.2 SIM HEC Approval



**SIM HUMAN ETHICS COMMITTEE**  
**Comments on Application for Human Ethics Approval**

Date: 29 October 2014

Principal Researcher: Lauren Bennett

Research Project: Capturing information technology use by secondary school students in New Zealand

Supervisor: Janet Toland

Reference No: 21472

<b>X</b>	Category 1: Accept
	Category 2: Accept with minor changes. (Stated below)
	Category 3: Accepted with required changes. (Stated below)
	Category 4: Do not accept in present form. (Changes required as below)


**Required Changes** (dealing with ethical issues only)

None.

NOTE: The applicant is to be congratulated for the effective emendation of what was quite a complex application requiring considerable thought and, at times, significant changes. Well done.

SCHOOL OF INFORMATION MANAGEMENT  
 FACULTY OF COMMERCE AND ADMINISTRATION

## A4.3 Participation information sheet for students



TE WHARE MĀHARAU O TE TŪKŪO O TE WAI PŪMĀHĪ  
**VICTORIA**  
UNIVERSITY OF WELLINGTON

**SCHOOL OF INFORMATION MANAGEMENT**  
TE KURA TIARI, WHAKAWHITI KŌRERO  
LEVEL 5, RUTHERFORD HOUSE, PIPITEA CAMPUS, 23 LAMBTON QUAY, WELLINGTON  
PO Box 600, Wellington 6140, New Zealand  
Phone +64-4-463 5103 Fax +64-4-463 5446 Email [sim@vuw.ac.nz](mailto:sim@vuw.ac.nz) Website [www.victoria.ac.nz/sim](http://www.victoria.ac.nz/sim)

### Participant Information Sheet for Students

**Research Project Title: Capturing information technology use by secondary school students in New Zealand**  
**Researcher: Lauren Bennett, School of Information Management, Victoria University of Wellington**

As part of the completion of my PhD this study is designed to examine the use of fast fibre technologies enabled by the rollout of broadband in New Zealand in education, specifically by senior school students, by identifying which technologies are used, exploring how the technologies are used in learning, and by developing a framework of how fast fibre technologies are used in education. This study will contribute to the theoretical understanding of use in information systems, by proposing a nuanced and responsive conceptualisation of the use of information technology artefacts in education; and a practical understanding of how technology is used in the classroom. Victoria University requires, and has granted, approval from the School's Human Ethics Committee.

I am inviting classes of year 12 and 13 secondary school students and their teachers to participate in this research. Participants will be observed in a classroom setting. Students will be asked to complete a questionnaire after classes; any discussion about the questionnaire may be used as data. Completed work by students may be collected; grades will not be collected.


Participation is voluntary. The students will not be identified personally, nor will your school be identifiable in any written report produced as a result of this research, including possible publication in academic conferences and journals. All material collected will be kept confidential, and will be viewed only by myself and my supervisors, Janet Toland, Programme Director, School of Information Management, and Bronwyn Howell, School of Management. The thesis will be submitted for marking to the School of Information Management, and subsequently deposited in the University Library. Should any participant wish to withdraw from the project, they may do so until 20 July 2017, and the data collected up to that point will be destroyed. All data collected from participants will be destroyed within five years after the completion of the project.

I am seeking your consent to participate in this project. If you have any questions or would like to receive further information about the project, please contact me at [Lauren.Bennett@vuw.ac.nz](mailto:Lauren.Bennett@vuw.ac.nz) or telephone 027 733 7749, or you may contact my supervisors Dr Janet Toland, Programme Director, School of Information Management at [Janet.Toland@vuw.ac.nz](mailto:Janet.Toland@vuw.ac.nz) or 04 463 6861, or Dr Bronwyn Howell, School of Management at [Bronwyn.Howell@vuw.ac.nz](mailto:Bronwyn.Howell@vuw.ac.nz) or telephone 04 463 5563.

Thank you.


Lauren Bennett  
School of Information Management, Victoria University of Wellington

## A4.4 Participant consent form for students

	<p>SCHOOL OF INFORMATION MANAGEMENT TE KURA TAKI, WHAKAHIHI KŌRERO LEVEL 5, RUTHERFORD HOUSE, PIRITEA CAMPUS, 23 LAMBTON QUAY, WELLINGTON PO Box 600, Wellington 6140, New Zealand Phone +64-4-463 5103 Fax +64-4-463 5446 Email <a href="mailto:sim@vuw.ac.nz">sim@vuw.ac.nz</a> Website <a href="http://www.victoria.ac.nz/sim">www.victoria.ac.nz/sim</a></p>
<b>Participant Consent Form for Students</b>	
<b>Research Project Title: Capturing information technology use by secondary school students in New Zealand</b>	
<b>Researcher: Lauren Bennett, School of Information Management, Victoria University of Wellington</b> <a href="mailto:Lauren.Bennett@vuw.ac.nz">Lauren.Bennett@vuw.ac.nz</a> 027 733 7749	
I have been given and have understood an explanation of this research project. I have had an opportunity to ask questions and have them answered to my satisfaction.	
I understand that I may withdraw myself (and any information I have provided) from this project, without having to give reasons, by e-mailing the researcher at <a href="mailto:lauren.bennett@vuw.ac.nz">lauren.bennett@vuw.ac.nz</a> by 20 July 2017.	
I understand that any information I provide will be kept confidential to the researcher and her supervisors, the published results will not use my name, and that no opinions will be attributed to me in any way that will identify me or my school.	
I understand that the data I provide will not be used for any other purpose or released to others.	
I understand that, if I am observed, notes of the observation will be destroyed within five years after the conclusion of the project.	
I understand that, if I answer a questionnaire the hard copies will be destroyed within five years after the conclusion of the project.	
I understand that if any of my submitted work is provided it will be destroyed within five years after the conclusion of the project.	
I understand that any discussion of the project with the researcher after I have given consent will be considered as part of the observation. Any notes of the discussion will be destroyed within five years after the conclusion of the project.	
Please indicate (by ticking the boxes below) which of the following apply:	
<input type="checkbox"/> I agree to participate in this research project. <input type="checkbox"/> I would like to receive a summary of the results of this research when it is completed. <input type="checkbox"/> I consent to allow my submitted work to be viewed by the researcher; the researcher will not view my grades.	
Email address for summary of results of the research:	
Name of participant:	
Signed:	Date:



## A4.5 Participant information sheet for guardians



TE WHARE WAKANUI O TE ORANGA KŌHĀ  
**VICTORIA**  
UNIVERSITY OF WELLINGTON

**SCHOOL OF INFORMATION MANAGEMENT**  
TE KURA TIANGI, WHAKAWHITI KŌRERO  
LEVEL 5, RUTHERFORD HOUSE, PIPITEA CAMPUS, 23 LAMINGTON QUAY, WELLINGTON  
PO Box 600, Wellington 6140, New Zealand  
Phone +64-4-463 5103 Fax +64-4-463 5446 Email [sim@vuw.ac.nz](mailto:sim@vuw.ac.nz) Website [www.victoria.ac.nz/sim](http://www.victoria.ac.nz/sim)

### Participant Information Sheet for Guardians

**Research Project Title: Capturing information technology use by secondary school students in New Zealand**  
**Researcher: Lauren Bennett, School of Information Management, Victoria University of Wellington**

As part of the completion of my PhD this study is designed to examine the use of fast fibre technologies enabled by the rollout of broadband in New Zealand in education, specifically by senior school students, by identifying which technologies are used, exploring how the technologies are used in learning, and by developing a framework of how fast fibre technologies are used in education. This study will contribute to the theoretical understanding of use in information systems, by proposing a nuanced and responsive conceptualisation of the use of information technology artefacts in education; and a practical understanding of how technology is used in the classroom. Victoria University requires, and has granted, approval from the School's Human Ethics Committee.

I am inviting classes of year 12 and 13 secondary school students and their teachers to participate in this research. Participants will be observed in a classroom setting. Students will be asked to complete a questionnaire after classes; any discussion about the questionnaire may be used as data. Completed work by students may be collected; grades will not be collected.


Participation is voluntary. The students will not be identified personally, nor will your school be identifiable in any written report produced as a result of this research, including possible publication in academic conferences and journals. All material collected will be kept confidential, and will be viewed only by myself and my supervisors, Janet Toland, Programme Director, School of Information Management, and Bronwyn Howell, School of Management. The thesis will be submitted for marking to the School of Information Management, and subsequently deposited in the University Library. Should any participant wish to withdraw from the project, they may do so until 20 July 2017, and the data collected up to that point will be destroyed. All data collected from participants will be destroyed within five years after the completion of the project.

If your child is under 16 years old I am seeking your consent for your child to participate in this project. If you have any questions or would like to receive further information about the project, please contact me at [Lauren.Bennett@vuw.ac.nz](mailto:Lauren.Bennett@vuw.ac.nz) or telephone 027 733 7749, or you may contact my supervisors Dr Janet Toland, Programme Director, School of Information Management at [Janet.Toland@vuw.ac.nz](mailto:Janet.Toland@vuw.ac.nz) or 04 463 6861, or Dr Bronwyn Howell, School of Management at [Bronwyn.Howell@vuw.ac.nz](mailto:Bronwyn.Howell@vuw.ac.nz) or telephone 04 463 5563.

Thank you.

Lauren Bennett  
School of Information Management, Victoria University of Wellington

## A4.6 Participant consent form for guardians

	<p>SCHOOL OF INFORMATION MANAGEMENT        TE KURA TIANGI, WHAKAAWHITI KÖRERO        LEVEL 5, RUTHERFORD HOUSE, PIPITEA CAMPUS, 23 LAMBTON QUAY, WELLINGTON        PO Box 600, Wellington 6140, New Zealand        Phone +64-4-463 5103 Fax +64-4-463 5446 Email sim@vuw.ac.nz Website www.victoria.ac.nz/sim</p>
<p><b>Participant Consent Form for Guardians</b></p>	
<p><b>Research Project Title: Capturing information technology use by secondary school students in New Zealand</b>  <b>Researcher: Lauren Bennett, School of Information Management, Victoria University of Wellington</b></p>	
<p>I have received a Participant Information Sheet for Guardian from my child. My child has been given and has understood an explanation of this research project. My child has had an opportunity to ask questions and have them answered to his or her satisfaction.</p>	
<p>I have had an opportunity to ask questions and have them answered to my satisfaction.</p>	
<p>I understand that my child may withdraw (and any information he or she has provided) from this project, without having to give reasons, by e-mailing the researcher at lauren.bennett@vuw.ac.nz by 20 July 2017.</p>	
<p>I understand that any information my child provides will be kept confidential to the researcher and her supervisors, the published results will not use my child's name, and that no opinions will be attributed in any way that will identify my child or my child's school.</p>	
<p>I understand that any data provided will not be used for any other purpose or released to others.</p>	
<p>I understand that any observation notes will be destroyed within five years after the conclusion of the project.</p>	
<p>I understand that any questionnaire will be destroyed within five years after the conclusion of the project.</p>	
<p>I understand that any submitted work will be destroyed within five years after the conclusion of the project.</p>	
<p>I understand that any data collected will be destroyed within five years after the conclusion of the project.</p>	
<p>Please indicate (by ticking the boxes below) which of the following apply:</p>	
<input type="checkbox"/>	<p>I consent to my child participating in this research project.</p>
<input type="checkbox"/>	<p>I would like to receive a summary of the results of this research when it is completed.</p>
<p>Email address for summary of results of the research:</p>	
<p>Name of participant:</p>	
<p>Name of guardian:</p>	
<p>Signed:</p>	<p>Date:</p>



## A4.7 Participation information sheet for teachers



SCHOOL OF INFORMATION MANAGEMENT  
TE KURA TIANGI, IHAKAWHITI KŌRERO  
LEVEL 5, RUTHERFORD HOUSE, FIRITEA CAMPUS, 23 LAMBTON QUAY, WELLINGTON  
PO Box 600, Wellington 6140, New Zealand  
Phone +64-4-463 5103 Fax +64-4-463 5446 Email [sim@vuw.ac.nz](mailto:sim@vuw.ac.nz) Website [www.victoria.ac.nz/sim](http://www.victoria.ac.nz/sim)

### Participant Information Sheet for Teachers

**Research Project Title: Capturing information technology use by secondary school students in New Zealand**

**Researcher: Lauren Bennett, School of Information Management, Victoria University of Wellington**  
[Lauren.Bennett@vuw.ac.nz](mailto:Lauren.Bennett@vuw.ac.nz)  
027 733 7749

As part of the completion of my PhD this study is designed to examine the use of fast fibre technologies enabled by the rollout of broadband in New Zealand in education, specifically by senior school students, by identifying which technologies are used, exploring how the technologies are used in learning, and by developing a framework of how fast fibre technologies are used in education. This study will contribute to the theoretical understanding of use in information systems, by proposing a nuanced and responsive conceptualisation of the use of information technology artefacts in education; and a practical understanding of how technology is used in the classroom. Victoria University requires, and has granted, approval from the School's Human Ethics Committee.

I am inviting classes of year 12 and 13 secondary school students and their teachers to participate in this research. Participants will be observed in a classroom setting. Teachers will be interviewed before class; permission will be asked to record the interview, and a transcript of the interview will be sent to participants for checking. Students will be asked to complete a questionnaire after classes; any discussion about the questionnaire may be used as data. Completed work by students may be collected; grades will not be collected.


Participation is voluntary. The students will not be identified personally, nor will your school be identifiable in any written report produced as a result of this research, including possible publication in academic conferences and journals. All material collected will be kept confidential, and will be viewed only by myself and my supervisors, Janet Toland, Programme Director, School of Information Management, and Bronwyn Howell, School of Management. The thesis will be submitted for marking to the School of Information Management, and subsequently deposited in the University Library. Should any participant wish to withdraw from the project, they may do so until 20 July 2017, and the data collected up to that point will be destroyed. All data collected from participants will be destroyed within five years after the completion of the project.

I am seeking your consent to participate in this project. If you have any questions or would like to receive further information about the project, please contact me at [Lauren.Bennett@vuw.ac.nz](mailto:Lauren.Bennett@vuw.ac.nz) or telephone 027 733 7749, or you may contact my supervisors Dr Janet Toland, Programme Director, School of Information Management at [Janet.Toland@vuw.ac.nz](mailto:Janet.Toland@vuw.ac.nz) or 04 463 6861, or Dr Bronwyn Howell, School of Management at [Bronwyn.Howell@vuw.ac.nz](mailto:Bronwyn.Howell@vuw.ac.nz) or telephone 04 463 5563.

Thank you.

Lauren Bennett  
School of Information Management, Victoria University of Wellington

## A4.8 Participant consent form for teachers

	<p><b>SCHOOL OF INFORMATION MANAGEMENT</b>          TE KURA TIARI, WHAKAWHITI KÖRERO          LEVEL 5, RUTHERFORD HOUSE, PIPITEA CAMPUS, 23 LAMBTON QUAY, WELLINGTON          PO Box 600, Wellington 6140, New Zealand          Phone +64-4-463 5103 Fax +64-4-463 5446 Email sim@vuw.ac.nz Website www.victoria.ac.nz/sim</p>
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**Participant Consent Form for Teachers**

**Research Project Title: Capturing information technology use by secondary school students in New Zealand**

**Researcher: Lauren Bennett, School of Information Management, Victoria University of Wellington**  
**Lauren.Bennett@vuw.ac.nz**  
**027 733 7749**

I have been given and have understood an explanation of this research project. I have had an opportunity to ask questions and have them answered to my satisfaction.

I understand that I may withdraw myself (and any information I have provided) from this project, without having to give reasons, by e-mailing the researcher at lauren.bennett@vuw.ac.nz by 20 July 2017.

I understand that any information I provide will be kept confidential to the researcher and her supervisors, the published results will not use my name, and that no opinions will be attributed to me in any way that will identify me or my school.

I understand that the data I provide will not be used for any other purpose or released to others.

I understand that, if I am observed notes of the observation will be destroyed within five years after the conclusion of the project.

I understand that, if I am interviewed and recorded, I will have an opportunity to check the transcripts of the interview. Furthermore the recording and transcripts of the interviews will be erased within five years after the conclusion of the project.

I understand that any discussion of the project with the researcher after I have given consent will be considered as part of the observation. Any notes of the discussion will be destroyed within five years after the conclusion of the project.

Please indicate (by ticking the boxes below) which of the following apply:

I agree to participate in this research project.


I would like to receive a summary of the results of this research when it is completed.

Email address for summary of results of the research:

Name of participant:

Signed: \_\_\_\_\_ Date: \_\_\_\_\_

## A4.9 Consent form for schools

 <p>TE WHARE WĀHANGA O TE ORANGA O TE WAIKŌRŌ <b>VICTORIA</b> UNIVERSITY OF WELLINGTON</p>	<p>SCHOOL OF INFORMATION MANAGEMENT TE KURA TIANGI, IHAKAWHITI KŌRERO LEVEL 5, RUTHERFORD HOUSE, PIPITEA CAMPUS, 23 LAMBTON QUAY, WELLINGTON PO Box 600, Wellington 6140, New Zealand Phone +64-4-463 5103 Fax +64-4-463 5446 Email <a href="mailto:sim@vuw.ac.nz">sim@vuw.ac.nz</a> Website <a href="http://www.victoria.ac.nz/sim">www.victoria.ac.nz/sim</a></p>
<b>Consent Form</b>	
<p><b>Research Project Title: Capturing information technology use by secondary school students in New Zealand</b> <b>Researcher: Lauren Bennett, School of Information Management, Victoria University of Wellington</b></p>	
<p>I have been given and have understood an explanation of this research project. I have had an opportunity to ask questions and have them answered to my satisfaction.</p>	
<p>I understand that any information provided will be kept confidential to the researcher and her supervisors, and the published results will not identify the school.</p>	
<p>I understand that the data provided will not be used for any other purpose or released to others.</p>	
<p>I understand that the data provided will be destroyed within five years after the conclusion of the project.</p>	
Signed:	Date: