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Capturing information technology use by senior secondary school students in New Zealand

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Abstract

The Ultrafast broadband rollout in New Zealand places a priority on delivering broadband to schools. The expectation that "Ultrafast broadband is transforming education" is moving schools to embed ICT in the classroom, placing pressure on limited budgets to further leverage already substantial investments. School principals are asking, what are the benefits of this investment?

This research in progress explores how students use digital technology, using critical realism and activity theory over multiple case studies, and finds that the technology available is diverse, multiple and malleable. A three-dimensional conceptualisation of these devices is proposed: as a tool for cognition, metacognition and distributed cognition. An example of collaborative work is used to elaborate how classes use multiple technologies along each of these dimensions, and how fast broadband supports these experiences. This study contributes by providing a guide to assess the potential use and usefulness of information technology in the classroom.

Keywords Activity theory, Broadband, Critical realism, Secondary schools, Use

1. Introduction

Ultrafast broadband is being rolled out around the world funded by billions of dollars of government money, including over $2 billion by the New Zealand government, because policy makers, providers and other stakeholders view this technology as a force for positive change. A key area for that potential is in education, and the New Zealand government has placed a priority on delivering broadband to schools as "Ultrafast broadband is transforming education" (Ministry of Education, 2015). However this rollout stops at the street. The Ministry of Education or the school pays for fibre to and Wireless Access Points through the school, and students pay for their devices under Bring Your Own Device. With schools under pressure to embed ICT in education, placing increasing pressure on limited budgets, school principals and trustees are asking, what are the benefits of this investment?

The literature on the introduction of broadband in education is equivocal. On the one hand national and international surveys have not been able to find widespread evidence of a concomitance between the introduction of fast broadband technology and significant and sustainable positive academic achievement (OECD, 2015; US Department of Education, 2010). On the other hand there are pockets of excellence and many examples of best practice to be found. Researchers have concluded that the benefits of the technology come not from its existence *per se*, but from its use.

Researchers have pointed to the need for a more realistic and more precise understanding of technology in education (Biesta, 2016; Hattie, 2015; Selwyn, 2011), including looking at instances where technology is not being used, or where technology is used in ways that suppress or disadvantage (Orlikowski, 1992). Researchers have identified that the mismatch between intentions and outcomes arises because there is a lack of knowledge of how students actually use the internet in their learning, and suggest focusing on the concept of use of technology in the classroom.

This research uses activity theory to explore the mediating role of internet enabled devices in the classroom. It identifies how these technological artifacts can be conceptualised as three-dimensional, as they mediate on three levels: distributed cognition, cognition, and metacognition. This research is conducted with the aim of providing a practical guide to how such tools help or hinder educational efforts, to leverage the already substantial investment in the technology.

2. Literature on use in information systems

Information Systems has a growing body of literature on "use", which can be used to inform research on use in education. This literature reflects Straub and del Giudice's call in their editorial in MIS Quarterly (2012) for more "thinking as to how we define, scope, and measure the use construct". IS researchers have moved from a traditional static view of IT use to models that view individual use behaviours as dynamically interacting and creating collective use patterns and outcomes.

Researchers are developing rich, complex, ensemble conceptualisations of use that are contextualised and informed by multiple theories and methodological stances, such as activity theory (Barki, Titah, & Boffo, 2007), adaptive structuration theory (Sedera & Tan, 2007), and complex adaptive systems (Nan, 2011). Models developed include Doll and Torkzadeh (1998), representation theory (Burton-Jones & Grange, 2013), and the process model of IT acceptance (Schwarz, Chin, Hirschheim, & Schwarz, 2014) (a complete table of use terms, theories, methodologies, and variables is available from the author).

These definitions have a certain degree of compatibility: they all require a user, a task and an IT artefact and system. Apart from that there is little in common. But they do show that in order to investigate the phenomena that emerge from the interaction of the technology artefact and the social system the first step is to develop a framework that can state "what is", which can often develop into theories that explain and predict by incorporating observations of what occurs in the real world.

3. Research objectives and questions

The objective of this research is to explore the role of broadband and internet enabled devices in the classroom, to understand how such tools help or hinder educational efforts, and how to move forward to make the most of substantial investments in the technology. The key initial research questions are:

- What technology do senior secondary school students use?
- How do students use the internet in their learning?

From these research questions we can ask how can our understanding of the use of the technology inform our practice?

4. Metatheoretical assumptions – Critical realism

This thesis adopts critical realism, a philosophy of science and social science originally developed by Bhaskar (1975, 1979). Critical realism is becoming more accepted in Information Systems and there are an increasing number of methodological papers in the discipline (Bygstad, Munkvold, & Volkoff, 2016; Zachariadis, Scott, & Barrett, 2013).

In critical realism the researcher observes and explicates the sequence of events which provides evidence for identifying the fundamental properties of structure, the tendencies of the structures to do certain things, and the context from which these events emerge. These tendencies are the basis for the hypothetical mechanisms that would cause or generate the event. This model of explanation allows researchers to develop in-depth causal explanations for the outcomes of specific sociotechnical phenomena that take into account the breadth of information technology, social, organizational, and environmental factors that may have played a causal role in their occurrence (Wynn & Williams, 2012).

5. Research methodology – Activity theory

The research uses activity theory as the methodological framework. In activity theory (Leontiev, 1977; Vygotsky, 1978) activity is viewed as a dialectic relationship between subject and object and this relationship is mediated by the tools used and the cultural and historical context within which the activity occurs. Researchers have noted a strong synergy between information systems and activity theory. This research uses third generation activity theory (Engeström, 1987, 2001); the structure of the theory is shown in Figure 1.

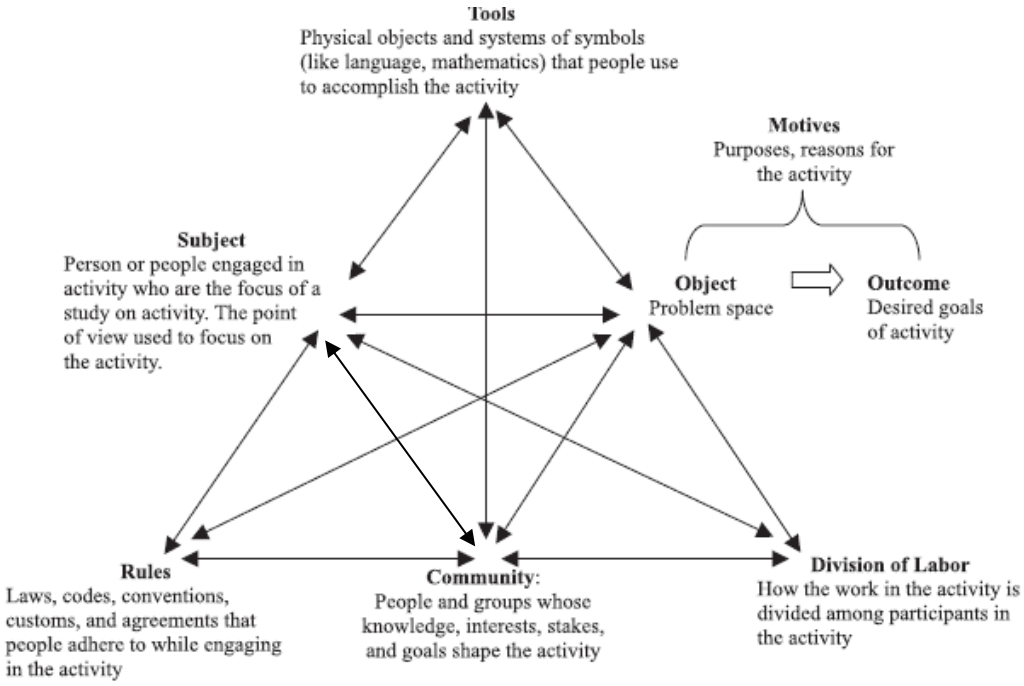

Figure 1: The structure of a human activity system, adapted from Engeström (Engeström, 2001).

Both critical realism and activity theory emphasise the explication of events. Activity theory was used to develop the research questions, the data collection instruments, and data coding. For example, rules which affected the use of the technology in the classroom were collected through asking the teacher what rules they imposed in their classrooms in their interviews, through asking the students what rules they obeyed in the questionnaires, and observing rules posted around the classroom. In critical realism the explication of events is important as it enables the researcher to identify the structures and mechanisms that may cause the events that are observed.

6. Research methods and data collection

This research uses qualitative, retroductive, multiple case studies, as it seeks to develop causal explanations of complex events (Wynn & Williams, 2012). A pilot study was undertaken in a single school, from which a three-dimensional understanding of the use of the technological artifact was

identified. Data was collected then collected from another three schools, which are listed by school and subject in Table 1.

School		Literacy			Numeracy			
A	Urban Private Single-sex Fibre	Year 13 History			Year 13 Accounting			
B	Regional Public Co-educational Fibre	Year 13 History Year 12 History				Year 13 Statistics		
C	Urban Private Single-sex VDSL		Year 12 English	Year 13 Media Studies		Year 13 Statistics		
D	Urban Integrated Single-sex Fibre		Year 13 English				Year 13 (1) Chemistry Year 13 (2) Chemistry	

Table 1: Cases by school and subject

There were multiple methods of data collection. As the unit of analysis in activity theory is human activity in context, observation to document actual behaviour is a key method of data collection, and each class was observed for at least five periods. The students completed a questionnaire, and the teachers were interviewed. Documents defining the NCEA standards from the Ministry of Education and class sets have been collected, as well as photographs of the educational setting.

7. Emerging findings

7.1 Explication of events

The explication of events answers the first question: What technology do senior secondary school students use? The answer is that they use a wide range of technology in multiple, varied and malleable ways (Schmitz, Teng, & Webb, 2016). Every student used a device to access the internet, and most had the devices to hand all the time they were observed. The devices were predominantly their own laptops and their own smartphones. The proportion of school owned laptops to student owned laptops depended on the school population. Tablets and desktops were accessed irregularly. Chromebooks were more popular than Apple laptops. However, once you included phones, and at least one student was writing their work on a phone, then the students were using multiple operating systems, including DOS, iOS and android.

The schools used different Learning Management Systems, and teachers used different systems within schools. Google Classrooms was used in two classes, but many teachers simply posted to Google Drive. An example of the malleability of technology in schools is that in one class the teacher used a proprietary system to post subject resources, collected work done by the students on Google Docs by sharing with the class, which sent share notifications via email.

The students were directed to websites external to the school, such as specialist statistics, chemistry and history websites. They were also empowered to research their topic deeper through their own means, for which the students used public sites such as Google and YouTube.

Key to understanding the event, and being able to analyse the structure and context, is realising that "learning is a function of information" and that students learn when they experience information, (Nuthall, 2007). Students' experiences with information are generally dispersed and disorganised. Even in tightly structured activities information is not encountered in neatly packaged, sequentially organised units. And even if it was, the students' encounter with the information is individual: each student interprets it, and sees its implications and connections in different ways. Each student will learn

different things from the same lesson. How students use the technology in their information experiences can be further analysed using activity theory.

7.2 Explication of structures and context

Third generation activity theory was used to identify the structures and context from the events observed in the classroom, and the actions and operations of the students. This enables the examination of the relationships between the concepts, and goes towards answering the question, how do students use the internet in their learning?

The **object** of the activity varied in every case, dependent on subject and task. But there was one overriding **objective** in all the classes: passing NCEA standards. In every class the teacher at least once stated how the work in the classroom related to the exam or the assessed work, or how extra credit was awarded. This shows the importance of the curriculum and examinations on learning.

The **division of labour** in all the cases was split between the teacher and the students. The teachers invariably started with the standard to be achieved, and the learning materials required for the standard. Supporting documents were provided by the teacher, whether that was a film, or hypertext links to external sources, as well as physical handouts and textbooks. In some classes it was possible to achieve the standard with an Excellence endorsement without seeking further information: the teacher provided the information, and the level of the endorsement depended on how well the students analysed and interpreted that information. In other classes the standard could not be achieved without seeking further information. For example, in a Statistics class students had to seek information on nutrition in McDonald's products, which could be done physically or virtually. The Media Studies class required research into film styles, which entailed watching many films, which could only be done online.

The **community** of the classes were generally contained in the classroom. There was a lot of individual work, although there was also paired work and small group work. The group work was used by teachers for collaboration and brainstorming of ideas. However, one teacher noted her experience of students copying another's work, and so limited the use of group work outside the classroom.

The wider school community had an impact on the classroom. Extra-curricular activity, including Education Outside the Classroom (field trips or camps), sports, arts (school production), culture (Kapa Haka), and service (charitable work), all impacted students attendance and attention in class.

There was some reference to the wider community: a Statistics class used a dataset of the sale prices of houses in the local area. A Chemistry class was going to the local university for a day as part of the university's outreach programme. The Media Studies class was asked to survey their community about their documentary, and their final work would be showcased to the school community. Bringing the community to the class was balanced with the requirement for individual work for assessment.

The **rules** about using technology were fairly relaxed in all schools in the senior classes. The teacher would be explicit, saying "screens down", and it was expected that all screens (laptops and phones) would be lowered while the teacher was speaking. One school had implemented a rule in the previous year that phones had to be away, or face down on the desk to minimise disruption. The teacher had been strict the previous year, but considered that the students had seen the rationale and benefits of the rule and had internalised this rule and was not as strict in enforcing it. Another teacher had a rule specific to her that the students could not watch videos during her class. Otherwise the teachers were relaxed about how the students used their devices to achieve the aims of the task, and all of the teachers expected and relied on the students' ability to self-manage.

Curiously the devices also enable to students to abide by and simultaneously evade other rules. For example, in a quiet classroom (quiet by classroom convention and rules) students S1 and S2 are on Facebook chat. S1 is across the aisle from S2. S2 turns around and gives earbuds to S1. The students are across the aisle, within arm's length. They do not touch and they do not talk.

7.3 Structures and mechanisms of use – the technological artifact

The technological artifacts used by students are multiple, varied and malleable, and importantly they are multipurpose – they are used to access the internet, but they are also used to complete tasks that do not access the internet. So a laptop can be used to write collaboratively in Google Docs, but also to write an essay offline for printing. A phone can be used to access chat on Facebook, or text on 3G. A tablet can be used to access a video on YouTube, or a photograph of work taken previously. For a classroom task it is possible, and probably, that a single device will be used for multiple purposes: a laptop to search on Google and write a document in Word. While this research focuses on the use of technology to access the internet, the affordances and capabilities of all aspects of the tools mediate what can be performed.

7.4 Structures and mechanisms of use – the three dimensions of the technological artifact

The explication of events, structures and context lead to uncovering and positing the mechanisms that can explain the use of technology in the classroom. The three dimensions of the technological artifact is derived from the students' activities, their actions and operations in the classroom. While there was variation in the object of the class, and in the type of tools used, the students' use of the devices were mediated three purposes, which have been conceptualised as distributed cognition (Cole & Engeström, 1993), metacognition (Engeström, 1987; Vygotsky, 1978) and cognition (Nuthall, 2012). This explication of events was used to develop a revised activity triangle with the expanded Tool vertex in Figure 2.

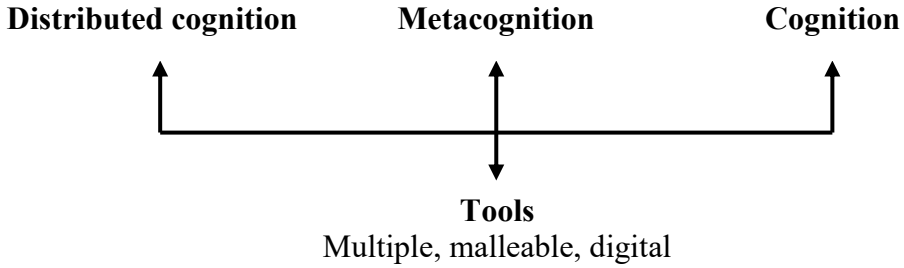

Figure 2: The tool vertex of the activity system showing the three dimensions of the technological artifact.

Metacognition is described by Engeström (1987, p. 139) as more than learning to learn, and requiring "(a) conscious analysis and mastery of not just discrete learning situations but of the continuous activity context in which the situations are embedded [...], (b) not just balancing the components of the learning situation but 'seeing through' the inherent contradictoriness of the learning tasks".

When asked if they think technology helps in their learning students said:

"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."

"Yes because I am able to search for information and get inspiration or clarify my own knowledge, mainly for finding evidence to back up my arguments or to explain something I don't fully understand. Using google docs is useful for completing and organising work and saving it for me online."

"I think that going online does help with my learning - there are so many resources online now that any questions I have I can try with google to figure out myself before asking other people."

The students use a wide range of technology and non-technology to enable learning; and they are quite sophisticated in their knowledge of self-management of their learning. They are aware when technology lets them zone out, and when the speed of calculation and automation can hide processes that they are meant to be learning.

Activity theory is invaluable when studying cognition as a distributed phenomenon (Cole & Engeström, 1993). **Distributed cognition** is the use of the devices to mediate the distribution of the cognition among the student, the device and the environment, as well as in the activity. The students said:

"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."

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

"Using google docs is useful for completing and organising work and saving it for me online."

The students use their devices to access required reading from the teacher, to save and organise their own work, and also to access wider research opportunities, and in all the classes the distributed cognition provided by the devices was a benefit noted by most students.

However, information that is distributed does not automatically equate with available. Teachers have reported that students who have not organised their online work into folders find it very difficult to complete their work. Also, the students have many places in which to distribute their work. One student, took a photo of shared hard copy work on a phone rather than have the work photocopied, for the ecological reason of saving paper; but the student did not save the photo to the work drive. The student was sure they would remember to access the photo for the assessment.

A key use of the technology is for communication with teachers and other students. Through sharing their documents cognition is distributed in their social world.

The most obvious use of the technology in schools is for **cognition**: the devices mediate how the students learn the curriculum content as well as the higher mental processes. Nuthall (1999) research shows that learning is a function of information. This means that this research does not need to uncover how working memory and fluid intelligence work (which is the subject of multitudinous research in psychology and biology, and far beyond the scope of this research), but rather identify the information the students experience, and how the information system can help or hinder that experience.

Some types of information identified by Nuthall are listed below with examples.

- Explicit item of information: information that the student needs to answer the item.
    - In School A Y13 History the students were given the key facts of the NZ Wars.
- Implicit or partial item of information: Some of the information the student needs, but not all of the information.
    - In School D Y13 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.
- Additional item of information or explanation, reasons and examples of the key concepts.
    - In School C Y13 Media Studies the students searched the internet for films to use as examples of film techniques (eg, point of view, camera work).
- Preparatory or contextual information that provides relevant background.
    - In School B Y12 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.
- Mention or reference to key words or concepts.
    - In School C Y12 English class two students seek definitions:
        - S_2 asks S_1 for definition of repenting.
        - S_5 googles for definition of cowardice, then uses online thesaurus.
    - In School D Y13 English the teacher asks the students to look up a word and suggests the dictionaries. All the students use their devices.

Once the structures and mechanisms have been explicated then we can identify how the mechanisms, the powers and liabilities of the digital tools, are realised during the classroom experience.

7.5 Structures and mechanisms of use – one example of the technological artifact in the dimensions of use

This understanding of the events, structures and context can be further used to analyse specific situations of learning in the classroom. One such example is how students work collaboratively. During this study there were four discrete events where students were tasked with working in pairs or threes to create a single piece of group work, that is, to work collaboratively. 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. Some studies have found that digital technologies are productive when they supports collaboration. The events were:

- School C, Year 12 English, used Google Docs to write up a set of notes;
- School D, both Year 13 Chemistry used Google Slides create a presentation; and

- School C, Year 13 Statistics used A3 sized paper to draft an outline of their assessment (the students were not allowed online as the answer had been uploaded to the LMC).

The events provide a nice comparison between technology and non-technology activities.

In English the teacher specifically asked the students to work in groups of three to answer three questions, to "share the mind", and to have a single student as secretary for this task. The majority of the class finished this task in twenty minutes. One group of students worked on a Google doc where they all contributed bullet points to each question. The only on task discussion was to say, "that is nice", "in relationship we should talk about", and "it's a love-hate relationship". At the end of the allotted time for the task they were working on presentation. In another group each student worked on their own question, and did not contribute to each other's answers. Only one group discussed what they would write for a collective answer, which was then written by a single student. When the task was stopped this group was still working on their final question.

In Chemistry the teacher asked the students to work together in pairs. All pairs retrieved past information for their work, as well as new information and figures and illustrations. There was very little discussion, but most students contributed to each slide. Only in one group was the work done by a single student, however the non-contributing student had to present the work at the end.

In Statistics the teacher asked the students to work in pairs or threes on A3 paper. Two of the groups drew flowcharts, one group drew a mind map, and one group added illustrations. There was discussion in each group, and the teacher was easily able to see when students were stuck.

The mechanisms of the event are realised in powers and liabilities of the technological artifacts. The power of the technology is in retrieving information: chemistry students could retrieve notes from a year ago, and also a wide range of information from the internet. This is a power of distributed cognition. The liabilities are that the technology is linear, and it is generally difficult, certainly with the technology and apps that were available, to produce work in the way that students think: with the mind maps or flowcharts which the students did easily with pen and paper. A number of studies look at how technology may inhibit the understanding of processes. There is also the question of how much of the work was collaborative, and how much was cumulative. These examples show there may be liabilities in using technology that can impact cognition.

8. Conclusion

Using activity theory has given rich data about the digital technology that students use in the classroom: it is diverse, multiple and malleable. The powers and liabilities of these devices directly mediate how students learn, when examined through the dimensions of cognition, metacognition and distributed cognition. This research will examine specific examples of technology use over multiple sites: exploring collaborative work, communication between the teacher and students, and a paradox between perception and use. It will look at how fast broadband supports these information experiences and their learning outcomes. The results will enable teachers and students in the classroom to consider the appropriateness and benefits of using the diverse examples of technology in the classroom for learning.

Broad and bold claims about the transformative powers of fast broadband have been made, and schools are under pressure embed ICT in the classroom, placing pressure on limited budgets. This research moves the focus from the presence of ICT in the classroom to the use of ICT in the classroom; it looks at how technology can supplement teaching, not replace it. Hopefully this will be produce a practical, user-centred guide to assess the use and usefulness of information technology, and contribute to the body of knowledge on how information can be developed into knowledge.

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